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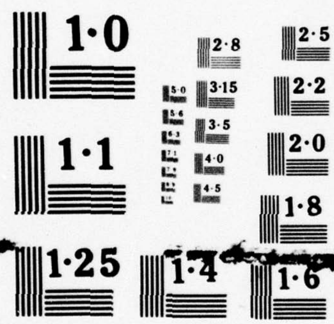


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CEEDO-TR-77-44

(SUPERSEDES AFCEC-TR-76-27; ADA 042053)

# DEVELOPMENT OF A PAVEMENT MAINTENANCE MANAGEMENT SYSTEM

## VOLUME II AIRFIELD PAVEMENT DISTRESS IDENTIFICATION MANUAL

CONSTRUCTION ENGINEERING RESEARCH LABORATORY
CHAMPAIGN, ILLINOIS 61820

DECEMBER 1977

FINAL REPORT FOR PERIOD
JULY 1974-JULY 1976



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CIVIL AND ENVIRONMENTAL ENGINEERING DEVELOPMENT OFFICE

(AIR FORCE SYSTEMS COMMAND)

TYNDALL AIR FORCE BASE

FLORIDA 32403

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This manual is designed to provide airfield pavement inspectors with a comprehensive reference for pavement distress identification. The information is to be used in conjunction with procedures presented in Volume I of this report to determine pavement condition and maintenance and repair requirements.

The types of airfield pavement distress are listed alphabetically under the major categories of asphalt- or tar-surfaced pavements and jointed concrete pavements. Names, descriptions, severity levels, photographs, and measurement -

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or count criteria are presented for each distress type.

## PREFACE

This report documents work accomplished between July 1974 and July 1976 by the U S Army Construction Engineering Research Laboratory under MIPR No. FQ 89527666005 from the Air Force Civil Engineering Center (AFCEC), Tyndall AFB, Florida. Mr Donald N. Brown was Project Engineer for the Civil Engineering Center.

On 8 April 1977 AFCEC divided into two organizations. AFCEC became part of the Air Force Engineering and Services Agency (AFESA). The Research and Development function remains under Air Force Systems Command as Det 1 (Civil and Environmental Engineering Development Office (CEEDO)) HQ ADTC. Both units remain at Tyndall AFB FL 32403.

To assure continuity of publication of the remaining volumes of this work effort, it is necessary to supersede the published AFCEC Technical Report. CEEDO is the sponsoring agency and Mr Donald N. Brown remains as the Project Engineer.

This report has been reviewed by the Information Officer (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Director Civil Engineering
Development

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Commander



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# SECTION I

# INTRODUCTION

## BACKGROUND

Maintenance, repair, and reconstruction of airfield pavements account for a large expenditure of funds by the U.S. Air Force. To ensure the optimum use of these funds, the Air Force requested the U.S. Army Construction Engineering Research Laboratory (CERL) to develop a pavement maintenance management system.

The system developed by CERL is based on the pavement condition index (PCI), a numerical indicator that reflects the structural integrity and surface operational condition of the pavement. (See Volume I of this report for a detailed discussion of the PCI.) Since the PCI relates the physical condition of the pavement to both structural integrity and operational condition, it can be used to determine maintenance, repair, and work planning needs.

The PCI is calculated based on the type, severity, and density of pavement distress as determined from pavement inspection. To obtain consistent and meaningful PCI values, distress identification and measurement must be based on a standardized reference. The distress descriptions in this manual were developed from numerous airfield condition surveys conducted by the authors and information in the literature.[1,2,3]

## OBJECTIVE

The objective of this manual is to provide pavement inspectors with a standardized reference for airfield pavement distress identification. The distress information is to be used in conjunction with the procedures presented in Volume I of this report to determine pavement condition and maintenance and repair requirements.

## USE OF THE MANUAL

The types of airfield pavement distress are listed alphabetically under the major categories of asphalt- or tar-surfaced pavements and jointed concrete pavements. Names, descriptions, severity levels, photographs, and

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[1] E. J. Barenberg, C. L. Bartholomew, and M. Herring, *Pavement Distress Identification and Repair*, Technical Report P-61/AD 758447 (Construction Engineering Research Laboratory [CERL], 1973).

[2] M. Y. Shahin, M. I. Darter, and F. M. Rozanski, *Pavement Inspection Reference Manual*, Technical Information Pamphlet C-48 (CERL, 1975).

[3] Standard Nomenclature and Definitions for Pavement Components and Deficiencies, Special Report No. 113 (Highway Research Board, 1970).

measurement or count criteria presented for each distress were established based on the effect of the pavement's structural integrity, operational condition, and maintenance and repair requirements.

It is very important that the pavement inspector be able to identify all distress types and their severity levels. The inspector should study this manual prior to performing an inspection and should carry a copy for reference during the inspection.

The results of the pavement inspection are to be used in conjunction with procedures developed in the companion report for determining the PCI and pavement rating (Figure 1). Inspection procedures, field data sheets, and procedures for determining the PCI are presented in Volume I of this report.

It should be emphasized that pavement inspectors must follow the distress descriptions in this manual in order to arrive at meaningful and consistent PCI values.

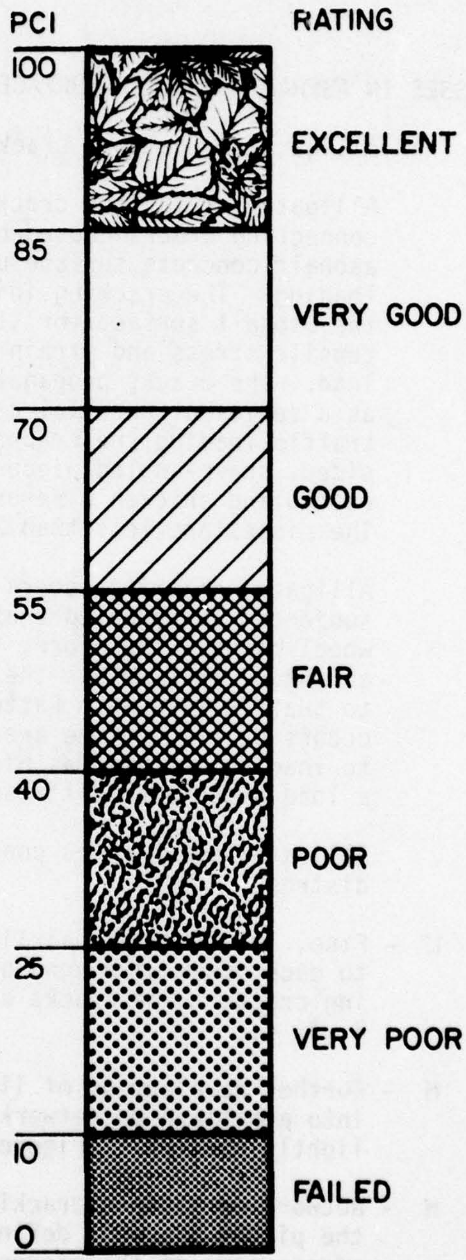



Figure 1. Airfield Pavement Condition Index (PCI) and Rating.

## SECTION II

## DISTRESSES IN ASPHALT- AND TAR-SURFACED PAVEMENTS

Name of Distress: Alligator or Fatigue Cracking

Description: Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. The cracking initiates at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain is highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 feet on the longest side.

Alligator cracking occurs only in areas that are subjected to repeated traffic loadings, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. Pattern-type cracking which occurs over an entire area that is not subjected to loading is rated as block cracking, which is not a load-associated distress.

Alligator cracking is considered a major structural distress.

Severity Levels:

L[4] - Fine, longitudinal hairline cracks running parallel to each other with none or only a few interconnecting cracks. The cracks are not spalled. (Figures 2, 3, 4)

M - Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled. (Figures 5 through 9)

H - Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges; some of the pieces rock under traffic. (Figure 10)

[4] L - Low severity level
M - Medium severity level
H - High severity level

How to Measure: Alligator cracking is measured in square feet of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present.

Figure 2. Low Severity Alligator Cracking.

Figure 3. Low Severity Alligator Cracking.

Figure 4. Low Severity Alligator Cracking, Approaching Medium Severity.

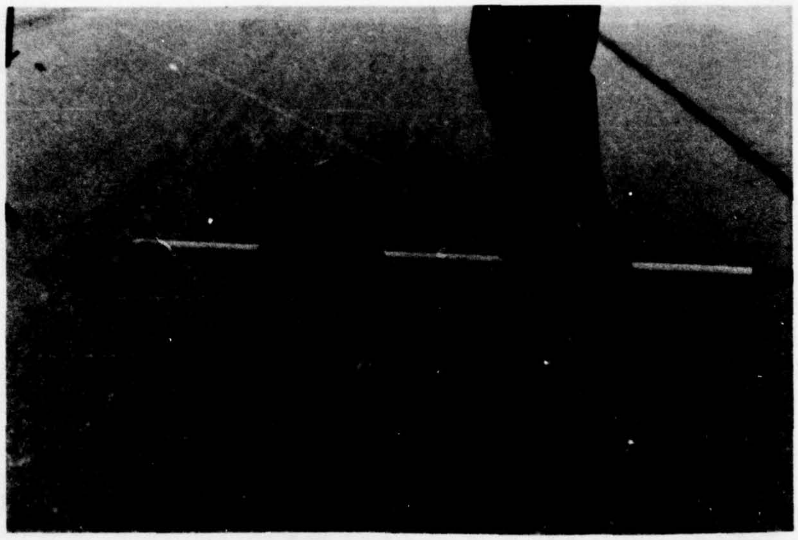


Figure 5. Medium Severity Alligator Cracking. (Note the Depression Occurring With the Cracking.)

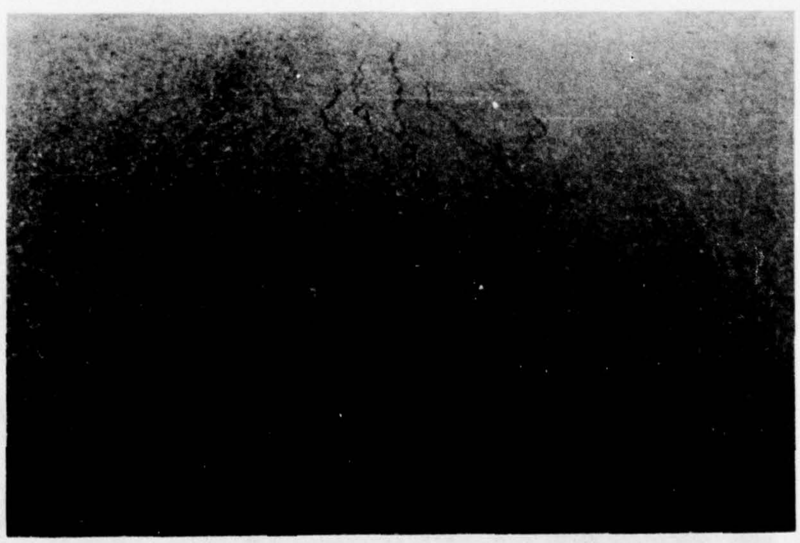


Figure 6. Medium Severity Alligator Cracking.

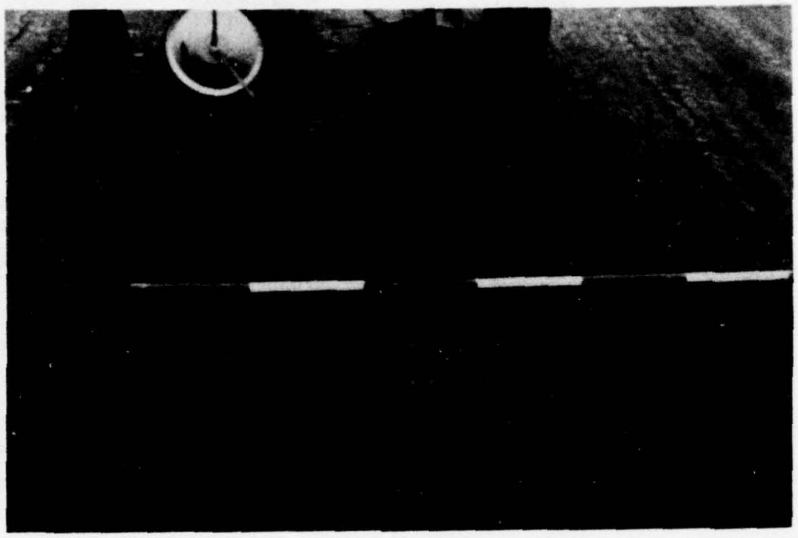


Figure 7. Medium Severity Alligator Cracking.

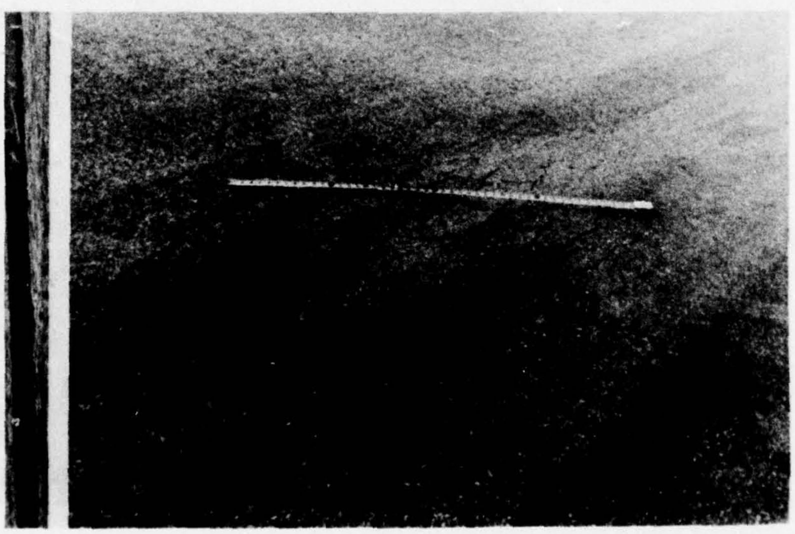


Figure 8. Medium Severity Alligator Cracking, Approaching High Severity.

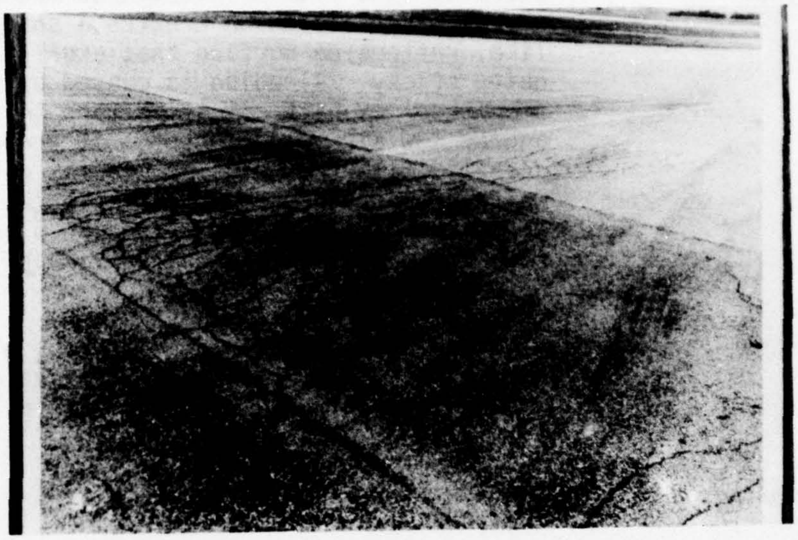


Figure 9. Medium Severity Alligator Cracking, Approaching High Severity.

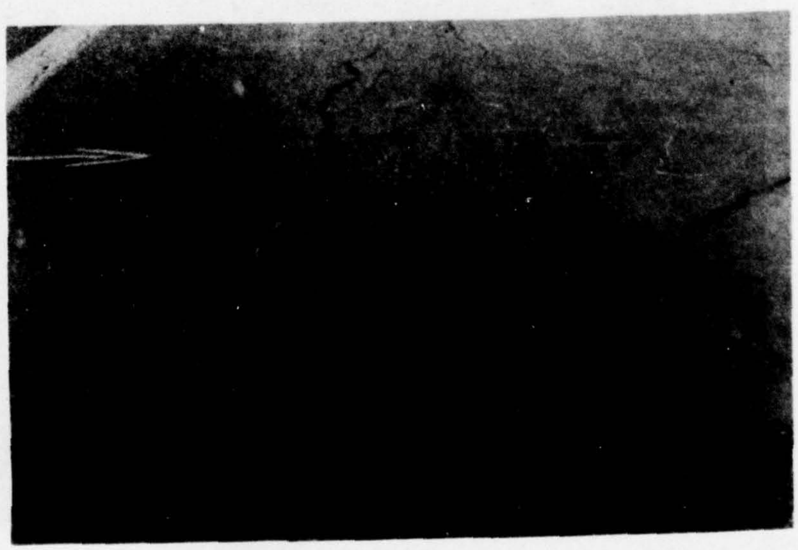


Figure 10. High Severity Alligator Cracking.

Name of Distress: Bleeding

Description: Bleeding is a film of bituminous material on the pavement surface which creates a shiny, glass-like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphalt cement or tars in the mix and/or low air void content. It occurs when asphalt fills the voids of the mix during hot weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels: No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance. (Figures 11, 12)

How to Measure: Bleeding is measured in square feet of surface area.

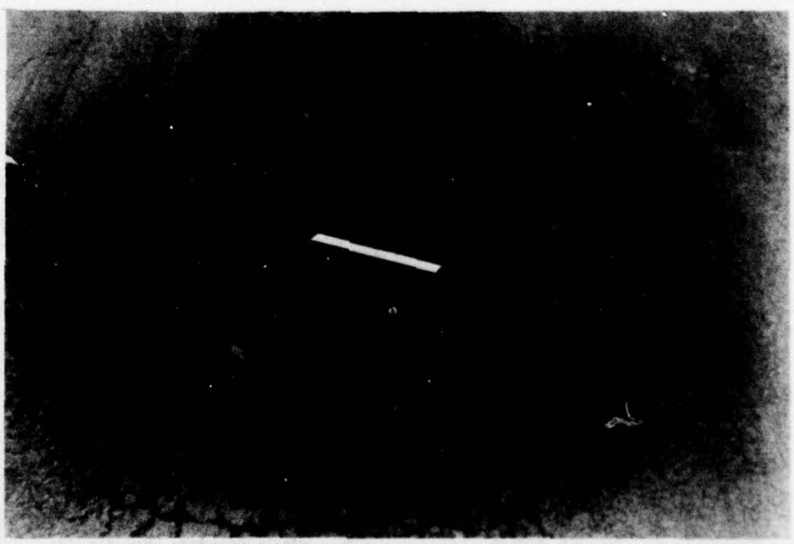


Figure 11. Bleeding.

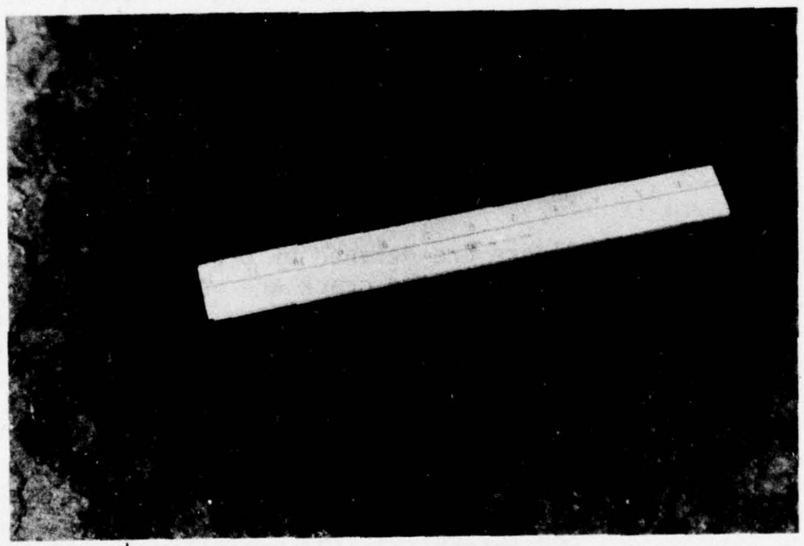


Figure 12. Close-Up of Figure 11.

Name of Distress: Block Cracking

Description: Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 x 1 foot to 10 x 10 feet. Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling). It is not load-associated. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large proportion of pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also unlike block cracks, alligator cracks are caused by repeated traffic loadings, and are therefore located only in traffic areas (i.e., wheel paths).

Severity Levels:

L - Blocks are defined by cracks that are nonspalled (sides of the crack are vertical) or only lightly spalled, causing no foreign object damage (FOD) potential. Nonfilled cracks have 1/4 inch or less mean width and filled cracks have a filler in satisfactory condition. (Figures 13 through 16)

M - Blocks are defined by either (1) filled or nonfilled cracks that are moderately spalled (some FOD potential); (2) nonfilled cracks that are not spalled or have only minor spalling (some FOD potential), but have a mean width greater than approximately 1/4 inch; or (3) filled cracks that are not spalled or have only minor spalling (some FOD potential), but have filler in unsatisfactory condition. (Figures 17, 18)

H - Blocks are well-defined by cracks that are severely spalled, causing a definite FOD potential. (Figures 19, 20, 21)

How to Measure: Block cracking is measured in square feet of surface area. It usually occurs at one severity level in a given pavement section; however, any areas of the pavement section having distinctly different levels of severity should be measured and recorded separately.

Figure 13. Low Severity Block Cracking.

Figure 14. Low Severity Block Cracking, Filled Cracks.

Figure 15. Low Severity Block Cracking, Filled Cracks.

Figure 16. Low Severity Block Cracking, Small Blocks Defined by Hairline Cracks.

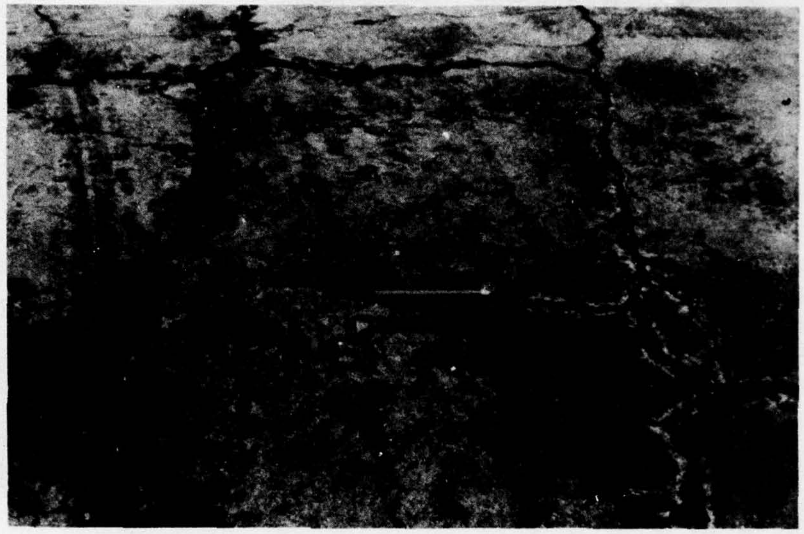


Figure 17. Medium Severity Block Cracking.

Figure 18. Medium Severity Block Cracking.


Figure 19. High Severity Block Cracking.

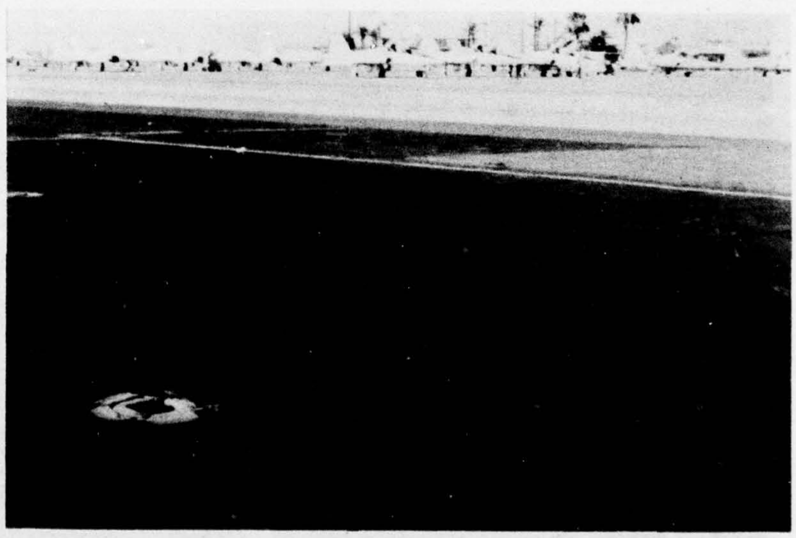


Figure 20. High Severity Block Cracking.

Figure 21. High Severity Block Cracking.

Name of Distress: Corrugation

Description: Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals (usually less than 5 feet) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress.

Severity Levels:

L - Corrugations are minor and do not significantly affect ride quality (see measurement criteria below). (Figure 22)

M - Corrugations are noticeable and significantly affect ride quality (see measurement criteria below.) (Figure 23)

H - Corrugations are easily noticed and severely affect ride quality (see measurement criteria below). (Figure 24)

How to Measure: Corrugation is measured in square feet of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10-foot straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches. The mean depth is calculated from five such measurements.

| Severity | Runways and High Speed Taxiways | Taxiways and Aprons |
|---|---|---|
| L | $<1/4$ inch | $<1/2$ inch |
| M | 1/4 - 1/2 inch | 1/2 - 1 inch |
| H | $\geq 1/2$ inch | $\geq 1$ inch |

Some of the following pictures have been taken on roads and streets. Corrugation is not commonly found on airfield pavements.

Figure 22. Low Severity Corrugation in the Foreground, Changing to Medium and High in the Background.

Figure 23. Medium Severity Corrugation.

Figure 24. High Severity Corrugation.

Name of Distress: Depression

Description: Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding of water. Depressions can be caused by settlement of the foundation soil or can be "built up" during construction. Depressions cause roughness and, when filled with water of sufficient depth, could cause hydroplaning of aircraft.

Severity Levels:

L - Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below). (Figure 25)

M - The depression can be observed, moderately affects pavement riding quality, and causes hydroplaning potential on runways (see measurement criteria below). (Figures 26, 27)

H - The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below). (Figure 28)

How to Measure: Depressions are measured in square feet of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10-foot straightedge across the depressed area and measuring the maximum depth in inches. Depression larger than 10 feet across must be measured by either visual estimation or direct measurement when filled with water.

Maximum Depth of Depression

| Severity | Runways and High Speed Taxiways | Taxiways and Aprons |
|---|---|---|
| L | 1/8 - 1/2 inch | 1/2 - 1 inch |
| M | >1/2 - 1 inch | >1 - 2 inches |
| H | >1 inch | >2 inches |

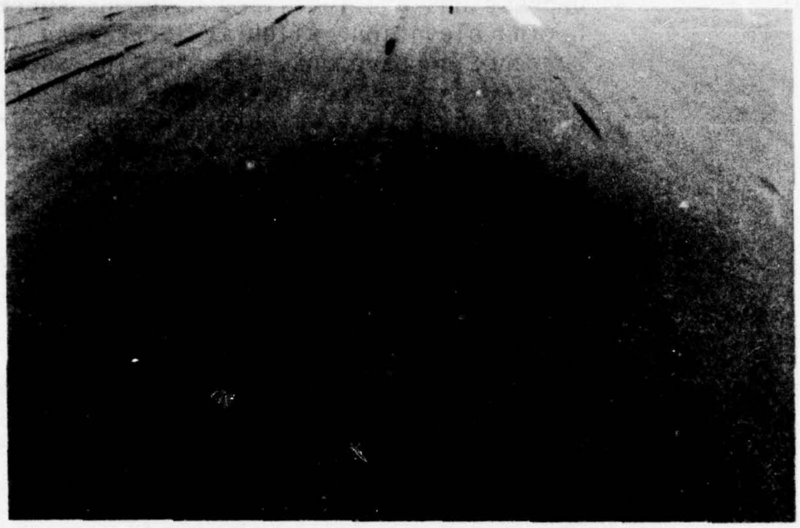


Figure 25.  Low Severity Depression.

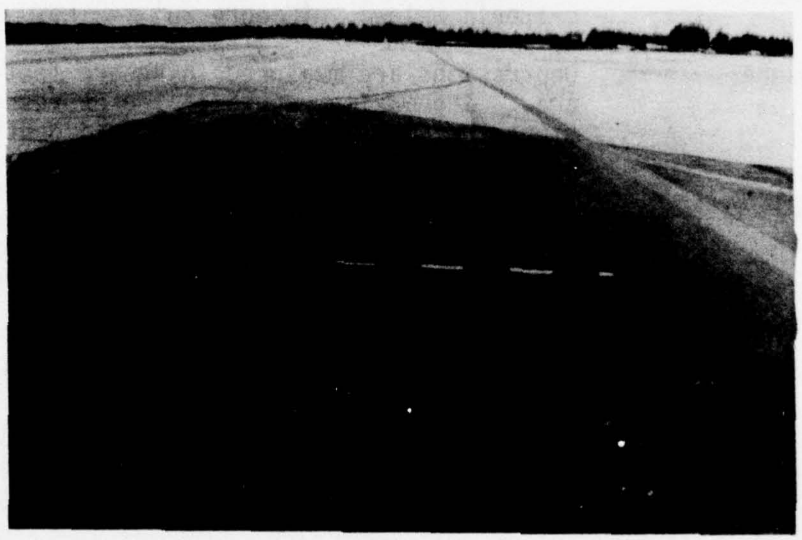


Figure 26.  Medium Severity Depression (> 1/2 Inch).

Figure 27. Medium Severity Depression (> 1/2 Inch).

Figure 28. High Severity Depression (2 Inches).

Name of Distress: Jet Blast Erosion

Description: Jet blast erosion causes darkened areas on the pavement surface where bituminous binder has been burned or carbonized; localized burned areas may vary in depth up to approximately 1/2 inch.

Severity Levels: No degrees of severity are defined. It is sufficient to indicate that jet blast erosion exists. (Figures 29, 30)

How to Measure: Jet blast erosion is measured in square feet of surface area.

Figure 29. Jet Blast Erosion.

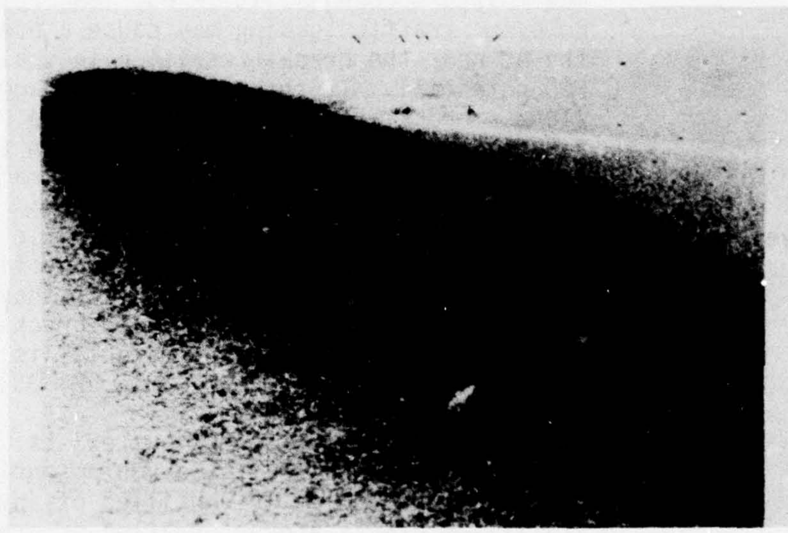


Figure 30. Jet Blast Erosion.

Name of Distress: Joint Reflection Cracking From PCC (Longitudinal and Transverse)

Description: This distress occurs only on pavements having an asphalt or tar surface over a portland cement concrete (PCC) slab. This category does not include reflection cracking from any other type of base (i.e., cement stabilized, lime stabilized); such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the asphalt concrete (AC) surface because of thermal and moisture changes; it is not load related. However, traffic loading may cause a breakdown of the AC near the crack, resulting in spalling and FOD potential. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels:

L - Cracks have only light spalling (little or no FOD potential) or no spalling, and can be filled or nonfilled. If nonfilled, the cracks have a mean width of 1/4 inch or less; filled cracks are of any width, but their filler material is in satisfactory condition. (Figures 31, 32, 33)

M - One of the following conditions exists: (1) cracks are moderately spalled (some FOD potential) and can be either filled or nonfilled of any width; (2) filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) nonfilled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4 inch; or (4) light random cracking exists near the crack or at the corners of intersecting cracks. (Figures 34, 35, 36)

H - Cracks are severely spalled (definite FOD potential) and can be either filled or nonfilled of any width. (Figure 37)

How to Measure: Joint reflection cracking is measured in linear feet. The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 feet long may have 10 feet of high severity, 20 feet of medium severity, and 20 feet of light severity; these would all be recorded separately.

Figure 31. Low Severity Joint Reflection Cracking.

Figure 32. Low Severity Joint Reflection Cracking, Filled Crack.

Figure 33. Low Severity Joint Reflection Cracking, Nonfilled Crack.

Figure 34. Medium Severity Joint Reflection Cracking.

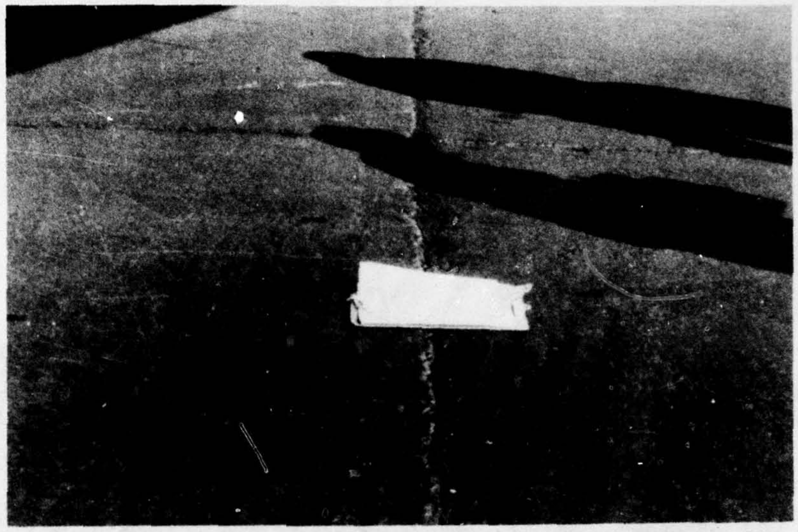


Figure 35. Medium Severity Joint Reflection Cracking.

Figure 36. Medium Severity Joint Reflection Cracking.

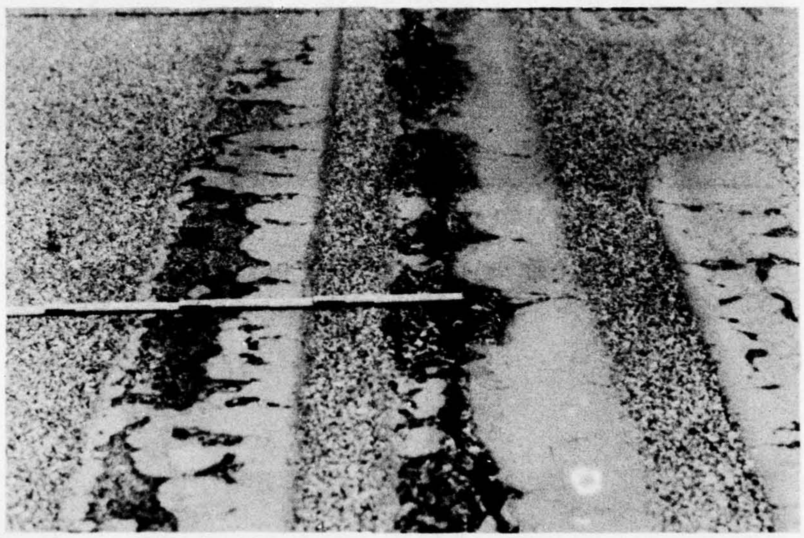


Figure 37. High Severity Joint Reflection Cracking.

Name of Distress: Longitudinal and Transverse Cracking (Non-PCC Joint Reflective)

Description: Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by (1) a poorly constructed paving lane joint, (2) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (3) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. They may be caused by items 2 or 3 above. These types of cracks are not usually load associated. If the pavement is fragmented along a crack, the crack is said to be spalled.

Severity Levels:

L - Cracks have either minor spalling (little or no FOD potential) or no spalling. The cracks can be filled or nonfilled. Nonfilled cracks have a mean width of 1/4 inch or less; filled cracks are of any width, but their filler material is in satisfactory condition. (Figures 38, 39)

M - One of the following conditions exists: (1) cracks are moderately spalled (some FOD potential) and can be either filled or nonfilled of any width; (2) filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) nonfilled cracks are not spalled or are only lightly spalled, but mean crack width is greater than 1/4 inch; or (4) light random cracking exists near the crack or at the corners of intersecting cracks. (Figures 40, 41, 42)

H - Cracks are severely spalled, causing definite FOD potential. They can be either filled or nonfilled of any width. (Figure 43)

How to Measure: Longitudinal and transverse cracks are measured in lineal feet. The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example, see Joint Reflection Cracking.

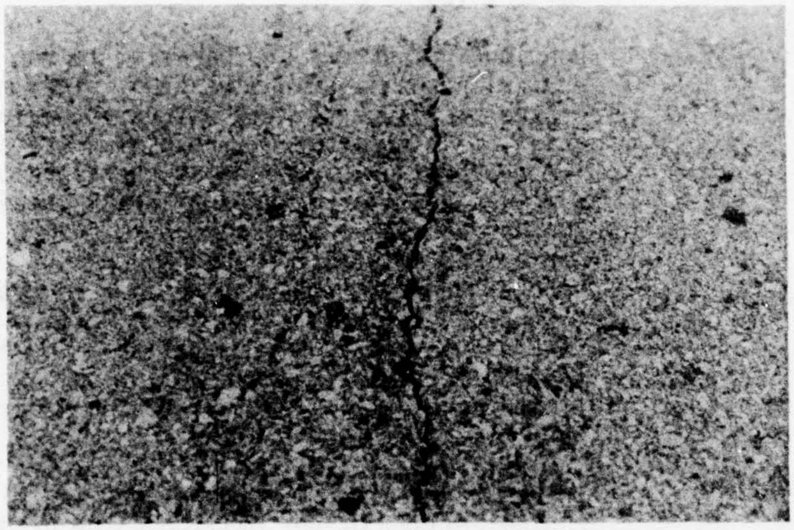


Figure 38. Low Severity Longitudinal Crack.

Figure 39. Low Severity Longitudinal Cracks, Approaching Medium.

Figure 40. Medium Severity Longitudinal Construction Joint Crack.

Figure 41. Medium Severity Longitudinal Crack. (Note the Crack Is Reflective But Not at the Joint of Slab.)

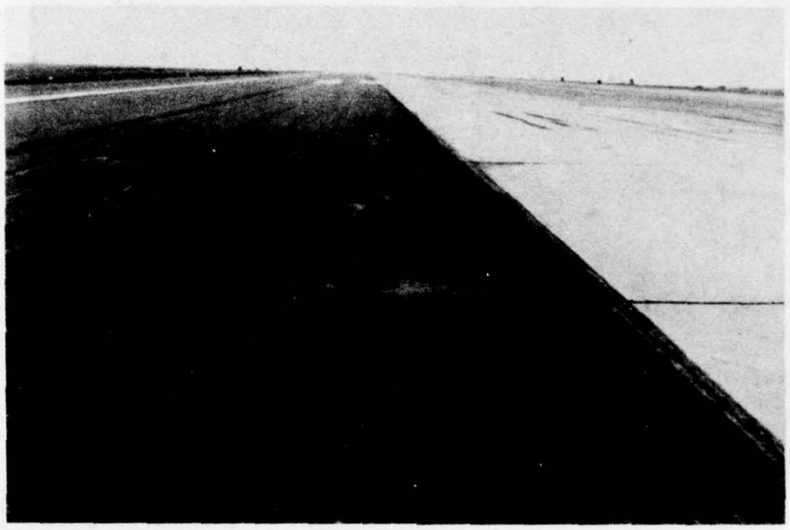


Figure 42. Medium Severity Longitudinal Crack.

Figure 43. High Severity Longitudinal Crack.

Name of Distress: Oil Spillage

Description: Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents. (Figures 44, 45)

Severity Levels: No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

How to Measure: Oil spillage is measured in square feet of surface area.

Figure 44. Oil Spillage.

Figure 45. Oil Spillage.

Name of Distress: Patching and Utility Cut Patch

Description: A patch is considered a defect, no matter how well it is performing.

Severity Levels:

L - Patch is in good condition and is performing satisfactorily. (Figures 46, 47, 48)

M - Patch is somewhat deteriorated and affects riding quality to some extent. (Figure 49)

H - Patch is badly deteriorated and affects ride quality significantly or has high FOD potential. Patch soon needs replacement. (Figure 50)

How to Measure: Patching is measured in square feet of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25 square foot patch may have 10 square feet of medium severity and 15 square feet of light severity. These areas would be recorded separately.

Figure 46. Light Severity Patch.

Figure 47. Light Severity Patch.

Figure 48. Light Severity Patch With Medium Severity Portion.

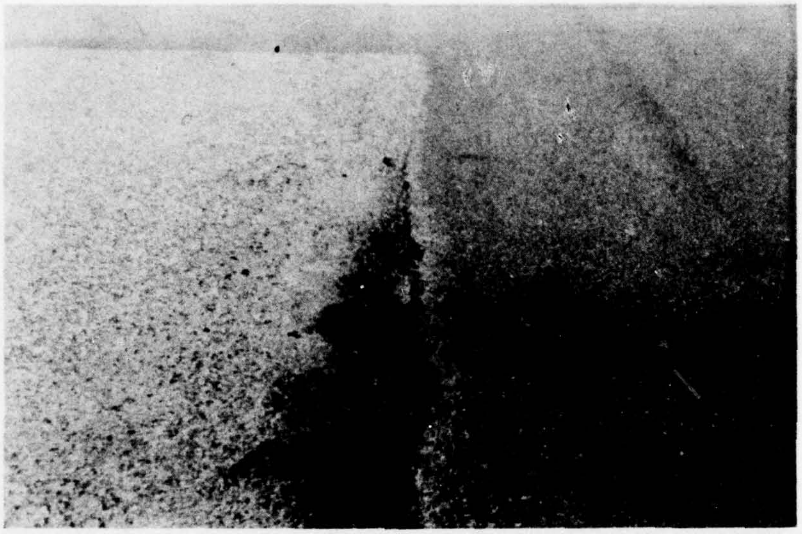


Figure 49.  Medium Severity Patch

Figure 50.  High Severity Patch.

Name of Distress: Polished Aggregate

Description: Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance. Existence of this type of distress is also indicated when the number on a skid resistance rating test is low or has dropped significantly from previous ratings.

Severity Levels: No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect. (Figure 51)

How to Measure: Polished aggregate is measured in square feet of surface area.

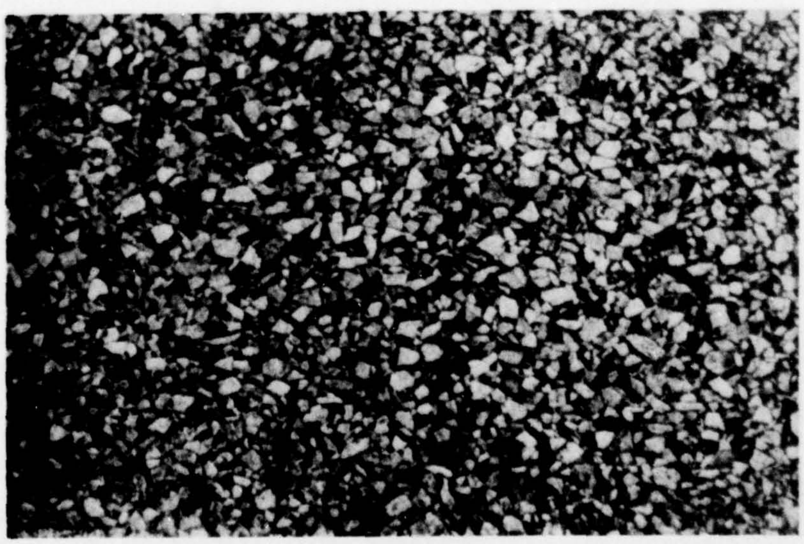


Figure 51. Polished Aggregate.

| | |
|---|---|
| Name of Distress: | Raveling and Weathering |
| Description: | Raveling and weathering are the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt or tar binder. They may indicate that the asphalt binder has hardened significantly. |
| Severity Levels: | L - Aggregate or binder has started to wear away, causing little or no FOD potential. (Figures 52, 53, 54) |
| | M - Aggregate and/or binder has worn away, causing some FOD potential. The surface texture is moderately rough and pitted. (Figure 55) |
| | H - Aggregate and/or binder has worn away, causing a high FOD potential. The surface texture is severely rough and pitted. (Figures 56, 57) |
| How to Measure: | Raveling and weathering are measured in square feet of surface area. |

Figure 52. Light Severity Raveling/Weathering.

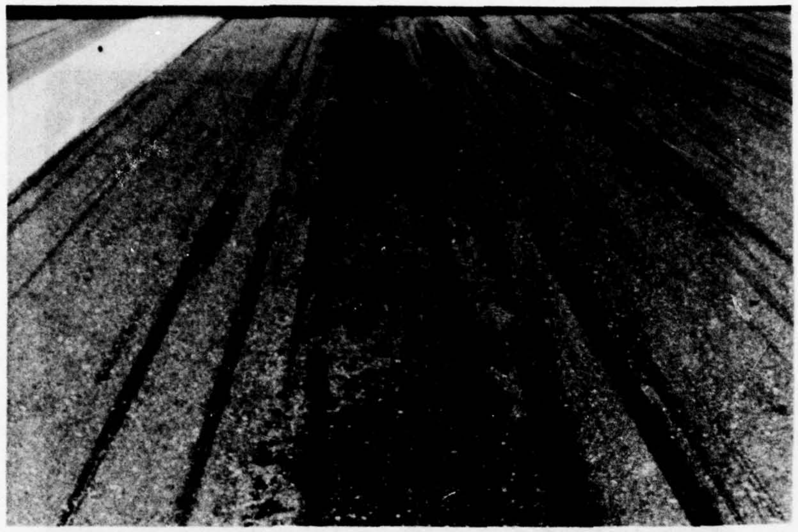


Figure 53. Light Severity Raveling/Weathering.

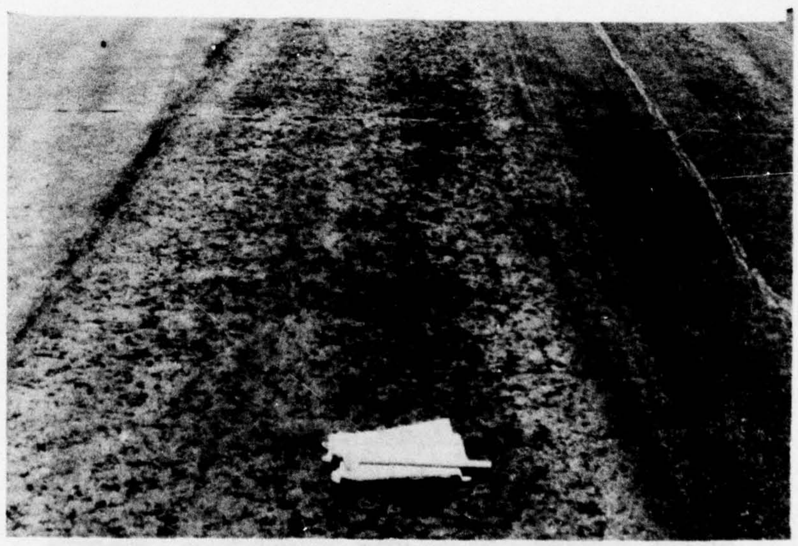


Figure 54. Light Severity Raveling/Weathering, Approaching Medium Severity.

Figure 55. Medium Severity Raveling/Weathering.

Figure 56. High Severity Raveling/Weathering.

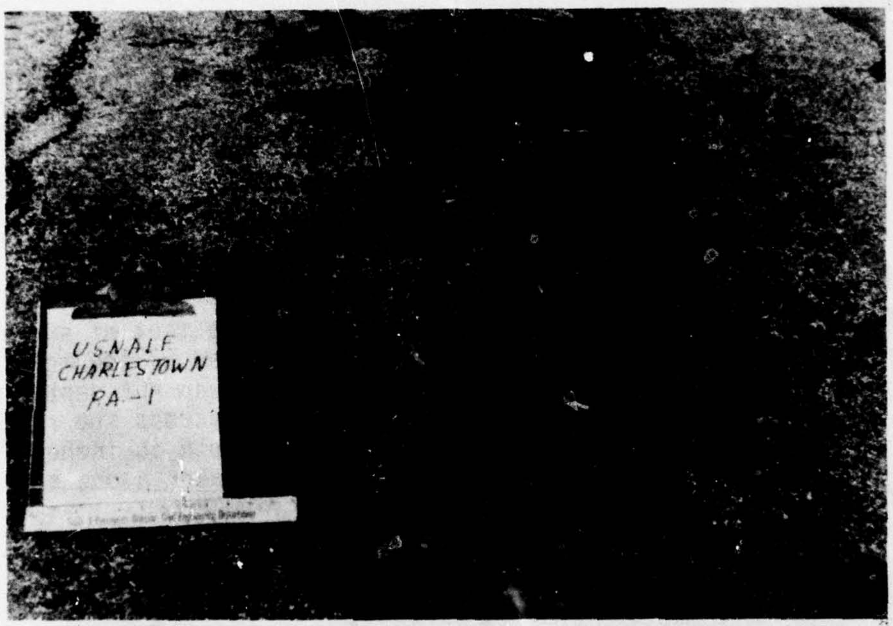



Figure 57. High Severity Raveling/Weathering.

| | |
|---|---|
| Name of Distress: | Rutting |
| Description: | A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidation or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement. |
| Severity Levels: | Mean Rut Depth Criteria |

| Severity | All Pavement Sections |
|---|---|
| L | 1/4 - 1/2 inch (Figures 58, 59) |
| M | >1/2 - 1 inch (Figure 60) |
| H | >1 inch (Figures 61, 62) |

| | |
|---|---|
| How to Measure: | Rutting is measured in square feet of surface area, and its severity is determined by the mean depth of the rut. To determine the mean rut depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches should be computed from measurements taken along the length of the rut. |

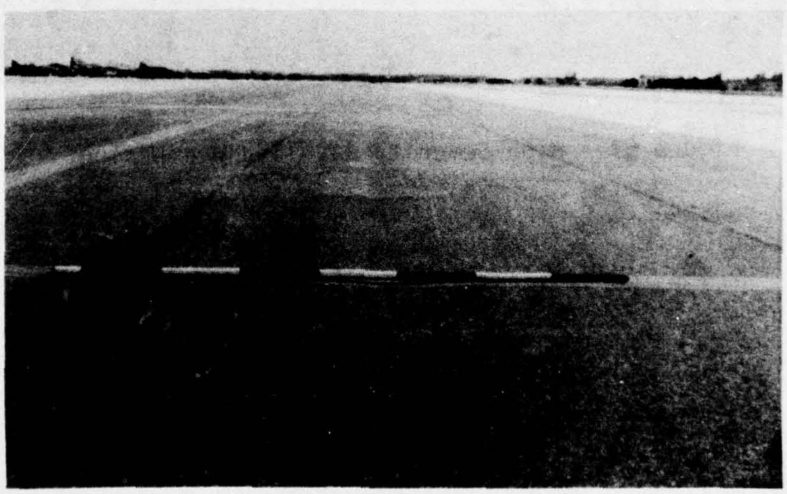


Figure 58. Light Severity Rutting.

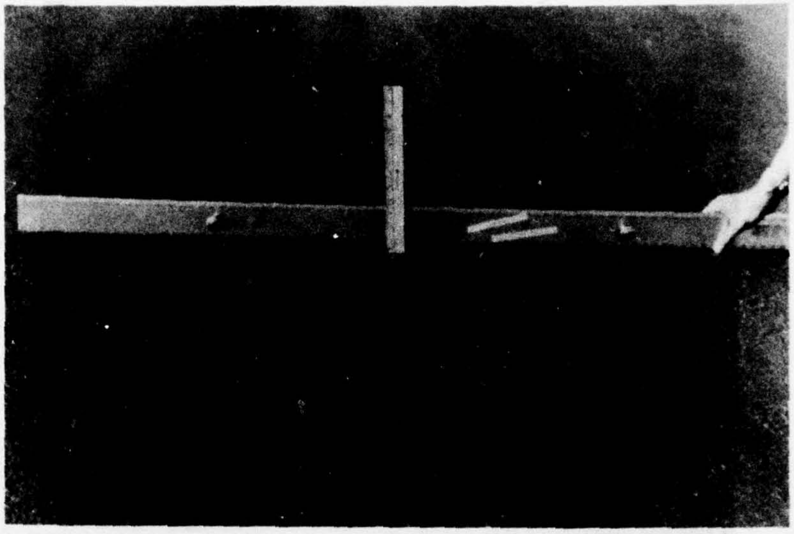


Figure 59. Light Severity Rutting.

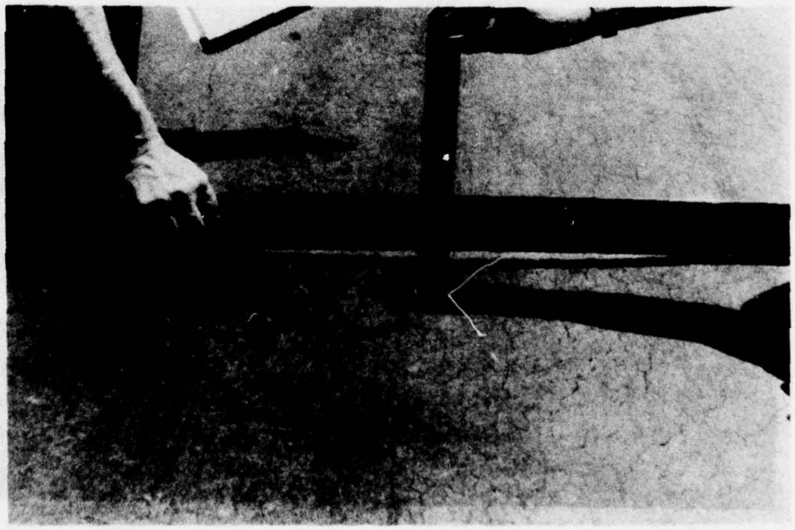


Figure 60. Medium Severity Rutting.

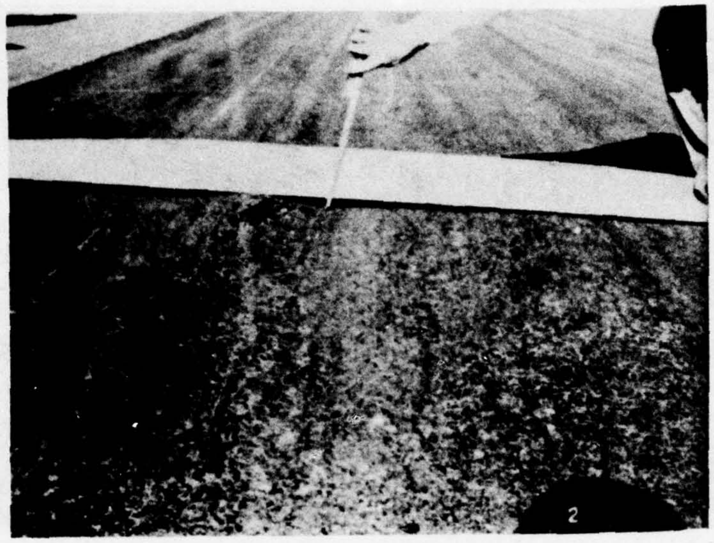


Figure 61. High Severity Rutting. (Note Alligator Cracking Associated With Rutting.)

Figure 62. High Severity Rutting. (Note Cracking and Upheaval on Sides of Rut.)

Name of Distress: Shoving of Asphalt Pavement by PCC Slabs

Description: PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as "pavement growth"). This "growth" shoves the asphalt- or tar-surfaced pavements, causing them to swell and crack. The PCC slab "growth" is caused by a gradual opening up of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Levels:

L - A slight amount of shoving has occurred, with little effect on ride quality and no break-up of the asphalt pavement. (Figure 63)

M - A significant amount of shoving has occurred, causing moderate roughness and little or no break-up of the asphalt pavement. (Figure 64)

H - A large amount of shoving has occurred, causing severe roughness or break-up of the asphalt pavement. (Figure 64)

How to Measure: Shoving is measured by determining the area in square feet of the swell caused by shoving.

Figure 63. This Photograph Shows a Shove of Low Severity on the Outside and Medium Severity in the Middle.

Figure 64. High Severity Shoving.

Name of Distress: Slippage Cracking

Description: Slippage cracks are crescent- or half-moon-shaped cracks having two ends pointed away from the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels: No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists. (Figures 65, 66)

How to Measure: Slippage cracking is measured in square feet of surface area.

Figure 65. Slippage Cracking.

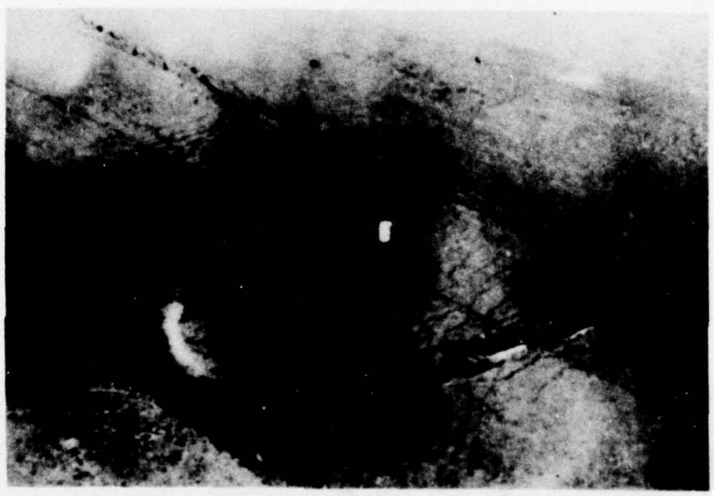


Figure 66. Slippage Cracking.

Name of Distress: Swell

Description: Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels:

L - Swell is barely visible and has a minor effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Low severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section at the normal aircraft speed. An upward acceleration will occur if the swell is present.) (Figure 67)

M - Swell can be observed without difficulty and has a significant effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Figure 68)

H - Swell can be readily observed and severely affects the pavement's ride quality at the normal aircraft speed for the pavement section under consideration. (Figure 69, 70)

How to Measure: The surface area of the swell is measured in square feet. The severity rating should consider the type of pavement section (i.e., runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on an apron or taxiway where the normal aircraft operating speeds are much lower. The following guidance is provided for runways:

| Severity | Height Differential |
|---|---|
| L | <3/4 inch |
| M | 3/4 - 1 1/2 inches |
| H | >1 1/2 inches |

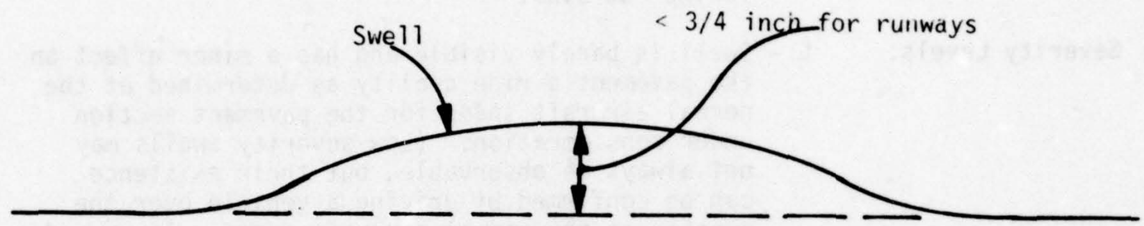



Figure 67. Low Severity Swell.

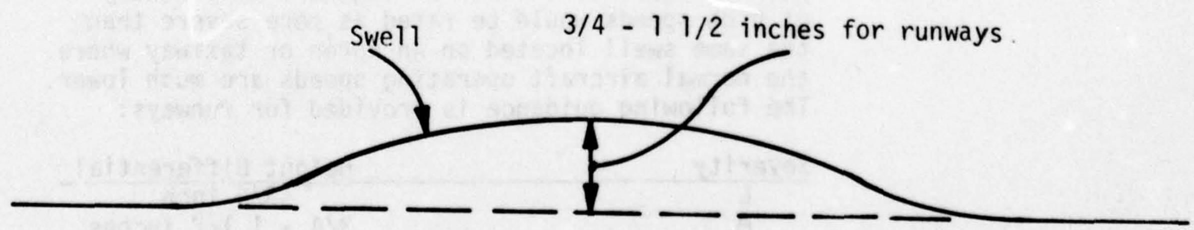



Figure 68. Medium Severity Swell.

Figure 69. High Severity Swell.

Figure 70. High Severity Sharp Swell.

SECTION III

## DISTRESSES ON JOINTED CONCRETE PAVEMENTS

Name of Distress: Blow-Up

Description: Blow-ups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. The insufficient width is usually caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blow-ups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. The main reason blow-ups are included here is for reference when closed sections are being evaluated for reopening.

Severity Levels:

L - Buckling or shattering has not rendered the pavement inoperative, and only a slight amount of roughness exists. (Figure 71)

M - Buckling or shattering has not rendered the pavement inoperative, but a significant amount of roughness exists. (Figure 72)

H - Buckling or shattering has rendered the pavement inoperative. (Figure 73)

NOTE: For the pavement to be considered operational, all foreign material caused by the blow-up must have been removed.

How to Count: A blow-up usually occurs at a transverse crack or joint. At a crack it is counted as being in one slab, but at a joint, two slabs are affected and the distress should be recorded as occurring in two slabs.

Figure 71. Low Severity Blow-Up. (Note That This Would Only Be Considered Low Severity If the Shattering in the Foreground Was the Only Part Existing and the Foreign Material Removed.)

Figure 72. Medium Severity Blow-Up.

Figure 73. High Severity Blow-Up.

Name of Distress: Corner Break

Description: A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 feet that has a crack intersecting the joint 5 feet from the corner on one side and 17 feet on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 feet on one side and 10 feet on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually causes corner breaks.

Severity Levels:

L - Crack has either no spalling or minor spalling (no FOD potential). If nonfilled, it has a mean width less than approximately 1/8 inch; a filled crack can be of any width, but the filler material must be in satisfactory condition. The area between the corner break and the joints is not cracked. (Figures 74, 75)

M - One of the following conditions exists: (1) filled or nonfilled crack is moderately spalled (some FOD potential); (2) a nonfilled crack has a mean width between 1/8 inch and 1 inch; (3) a filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition; (4) the area between the corner break and the joints is lightly cracked. (Figures 76, 77)

H - One of the following conditions exists: (1) filled or nonfilled crack is severely spalled, causing definite FOD potential; (2) a nonfilled crack has a mean width greater than approximately 1 inch, creating a tire damage potential; or (3) the area between the corner break and the joints is severely cracked. (Figure 78)

How to Count: A distressed slab is recorded as one slab if it (1) contains a single corner break, (2) contains more than one break of a particular severity, or (3) contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both light and medium severity corner breaks should be counted as one slab with a medium corner break.

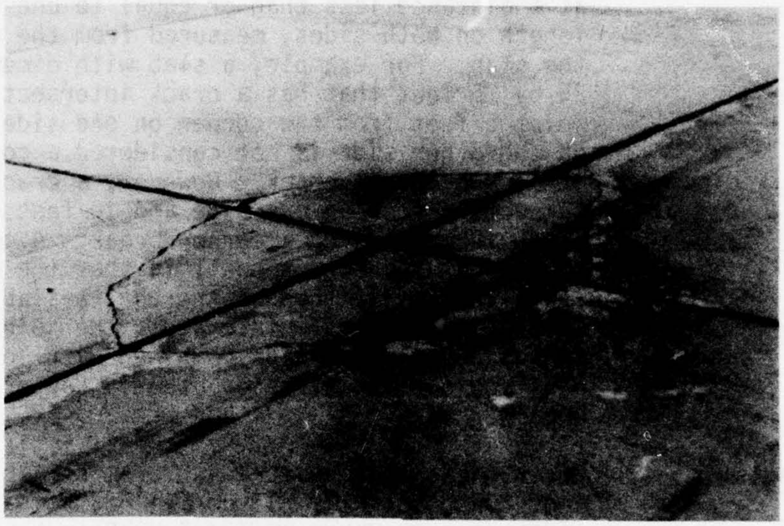


Figure 74.  Low Severity Corner Break.

Figure 75.  Low Severity Corner Break.

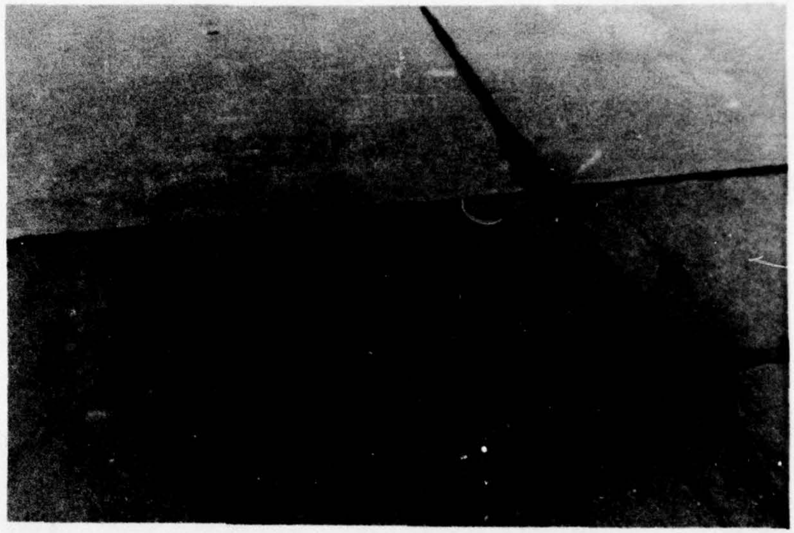


Figure 76. Medium Severity Corner Break. (Area Between the Corner Break and the Joints Is Lightly Cracked.)

Figure 77. Medium Severity Corner Break.

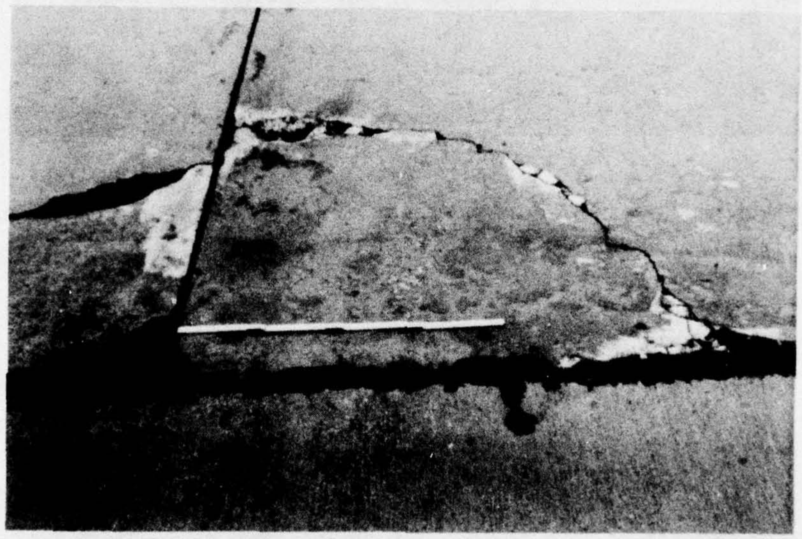


Figure 78. High Severity Corner Break.

Name of Distress: Longitudinal, Transverse, and Diagonal Cracks

Description: These cracks, which divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into six or more pieces see Shattered/Intersecting Cracks.) Low severity cracks are usually warping- or friction-related and are not considered major structural distresses. Medium or high severity cracks are usually working cracks and are considered major structural distresses.

NOTE: Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.

Severity Levels:

L - (1) crack has no spalling or minor spalling (no FOD potential). If nonfilled, it is less than 1/8 inch wide; a filled crack can be of any width, but its filler material must be in satisfactory condition. (Figures 79, 80, 81)

M - One of the following conditions exists: (1) a filled or nonfilled crack is moderately spalled (some FOD potential); (2) a nonfilled crack has a mean width between 1/8 inch and 1 inch; (3) a filled crack has no spalling or minor spalling, but the filler is in unsatisfactory condition; or (4) the slab is divided into three pieces by low severity cracks. (Figures 82, 83, 84)

H - One of the following conditions exists: (1) a filled or nonfilled crack is severely spalled (definite FOD potential); (2) a nonfilled crack has a mean width approximately greater than 1 inch, creating tire damage potential; or (3) the slab is divided into three pieces by two or more cracks, one of which is at least medium severity. (Figures 85, 86, 87)

How to Count: Once the severity has been identified, the distress is recorded as one slab.

Figure 79. Low Severity Longitudinal Crack.

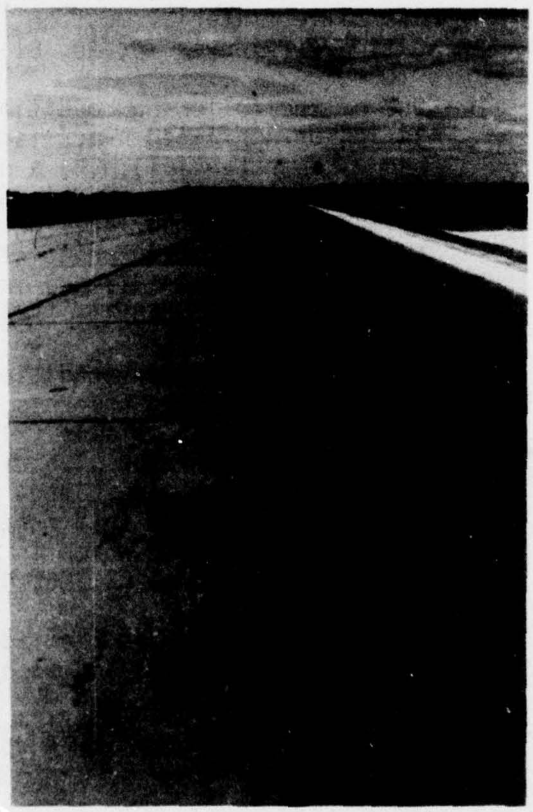


Figure 80. Low Severity Filled Longitudinal Cracks.

Figure 81. Low Severity Diagonal Crack.

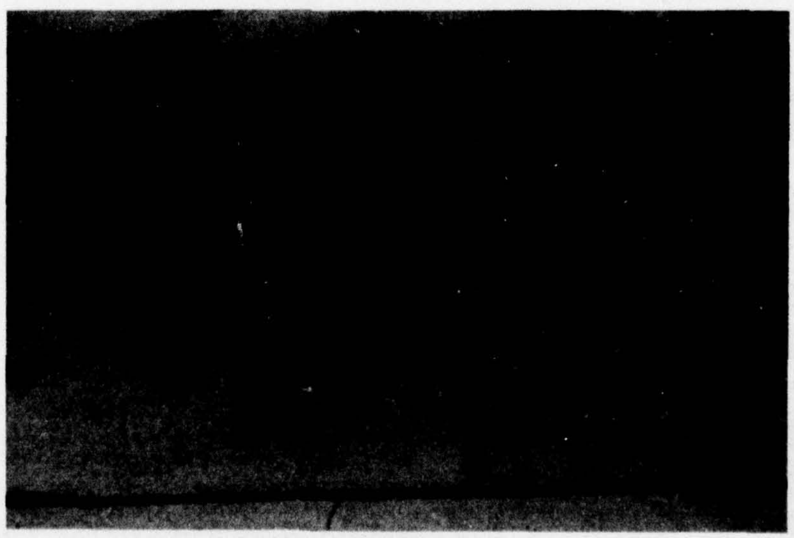


Figure 82. Medium Severity Longitudinal Crack.

Figure 83. Medium Severity Transverse Crack.

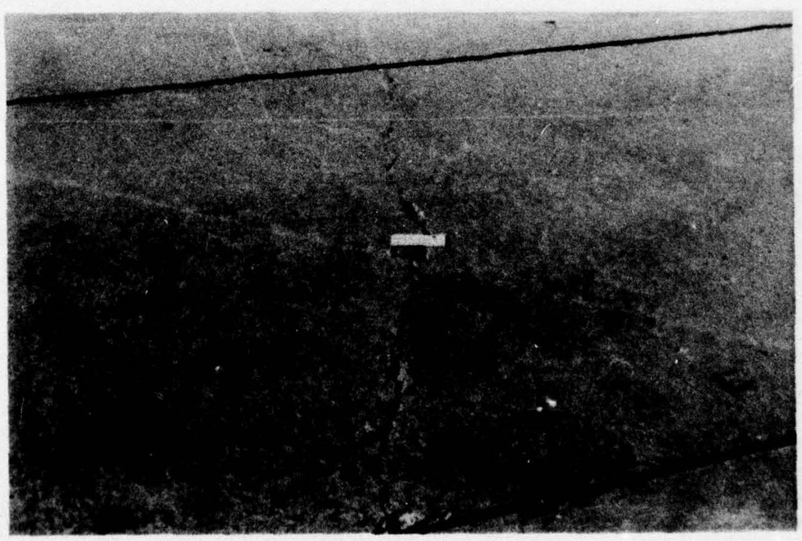


Figure 84. Medium Severity Transverse Crack.

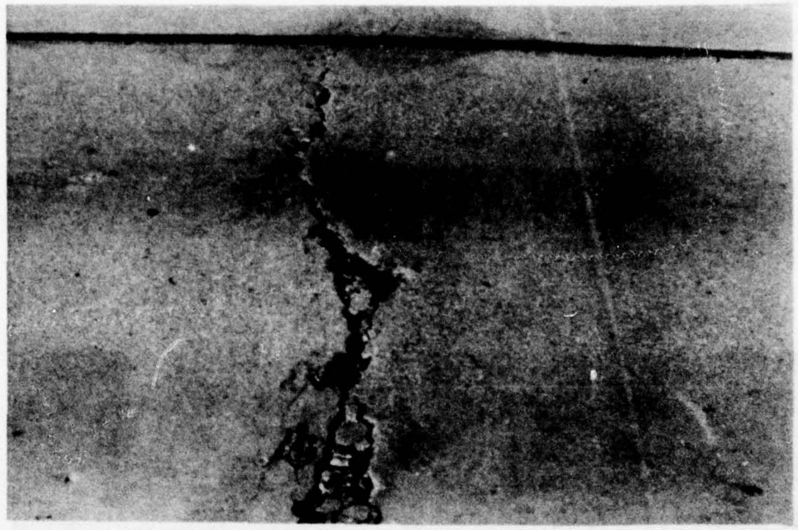


Figure 85. High Severity Crack.

Figure 86. High Severity Longitudinal Cracks.

Figure 87. High Severity Crack.

Name of Distress: Durability ("D") Cracking

Description: Durability cracking is caused by the concrete's inability to withstand environmental factors such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet of the joint or crack.

Severity Levels:

L - Pieces are defined by light cracks and cannot be removed; little or no FOD potential exists. (Figure 88)

M - "D" cracks are well defined; small pieces have been displaced, causing some FOD potential. (Figures 89, 90)

H - "D" cracking has developed over a considerable amount of slab area (greater than approximately one-quarter of the slab area) and the pieces are well defined and can be removed easily. The area is a considerable source of FOD potential. (Figure 91)

How to Count: When the distress is located and rated at one severity it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. For example, if light and medium durability cracking are located on one slab, the slab is counted as having medium only.

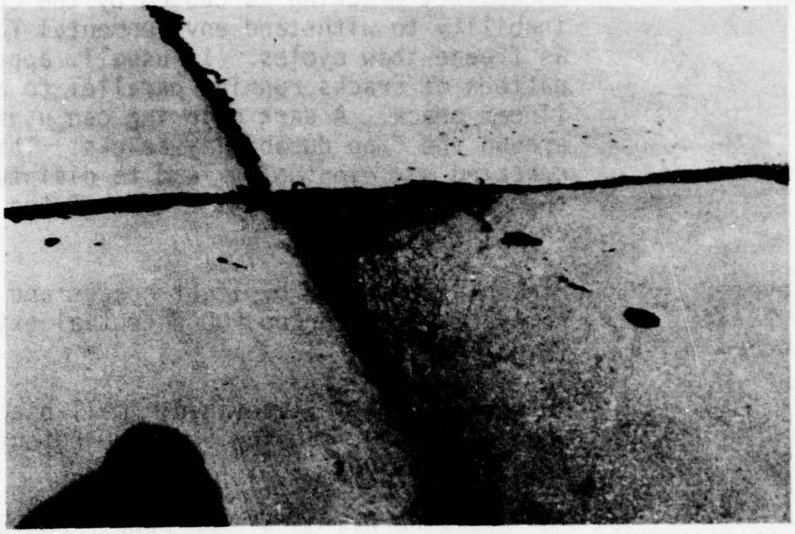


Figure 88. Low Severity "D" Cracking.

Figure 89. Medium Severity "D" Cracking.

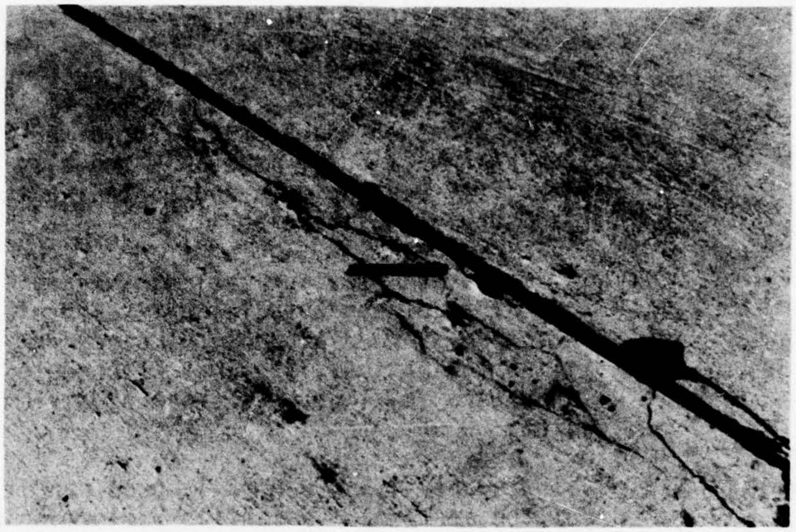


Figure 90. Medium Severity "D" Cracking.

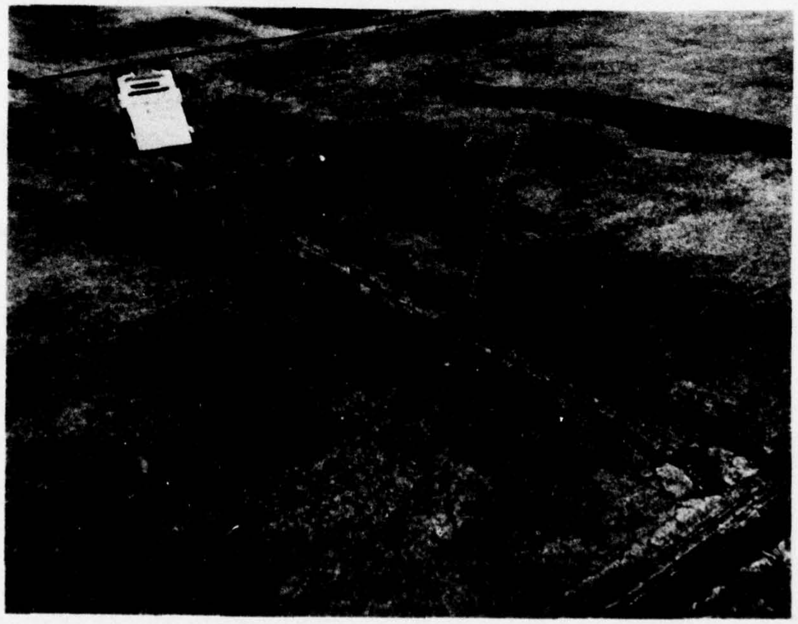


Figure 91. High Severity "D" Cracking. (This Condition Exists Over More Than One-Quarter of the Slab.)

Name of Distress: Joint Seal Damage

Description: Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant infiltration of water. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from accumulation of materials and also prevents water from seeping down and softening the foundation supporting the slab.

Typical types of joint seal damage are: (1) stripping of joint sealant, (2) extrusion of joint sealant, (3) weed growth, (4) hardening of the filler (oxidation), (5) loss of bond to the slab edges, and (6) lack or absence of sealant in the joint.

Severity Levels:

L - Joint sealer is in generally good condition throughout the section. Sealant is performing well with only a minor amount of any of the above types of damage present. (Figure 92)

M - Joint sealer is in generally fair condition over the entire surveyed section, with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years. (Figure 93)

H - Joint sealer is in generally poor condition over the entire surveyed section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement. (Figures 94, 95)

How to Count: Joint seal damage is not counted on a slab-by-slab basis, but is rated based on the overall condition of the sealant over the entire section.

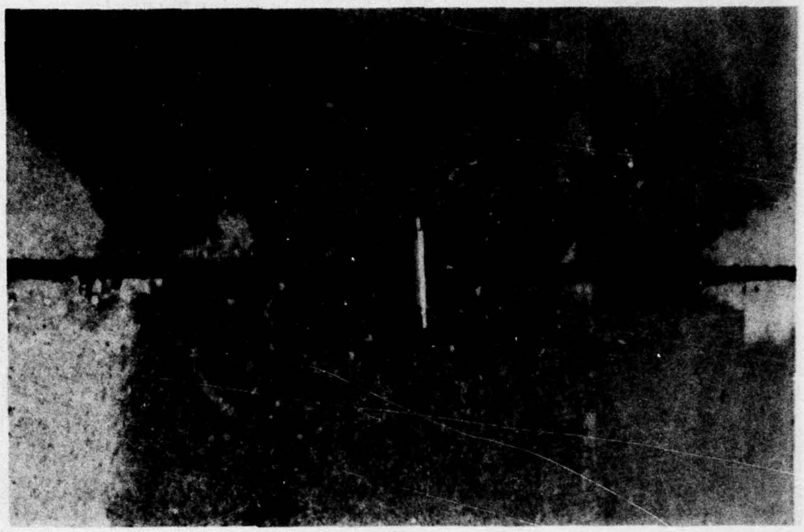


Figure 92. Light Severity Joint Seal Damage. (This Condition Existed Only on a Few Joints in the Pavement Section. If All Joint Sealant Were as Shown, It Would Have Been Rated Medium.)

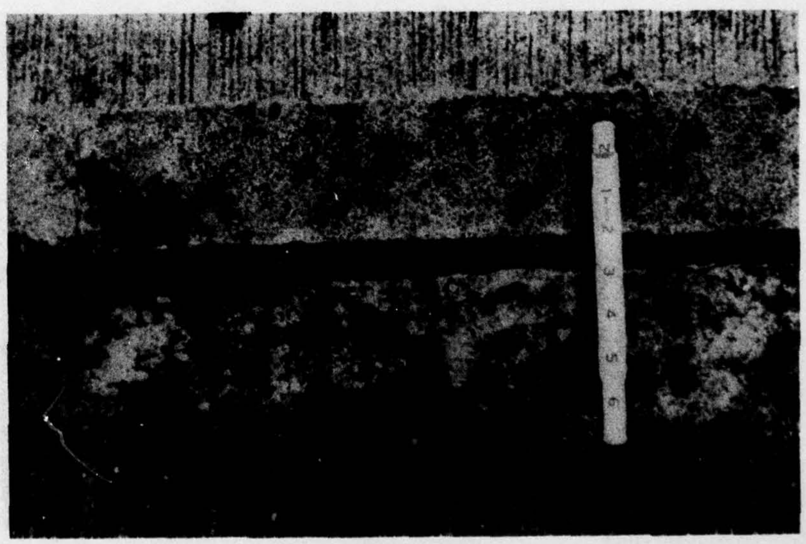


Figure 93. Medium Severity Joint Seal Damage. (Note That Sealant Ha Lost Bond and Is Highly Oxidized.)

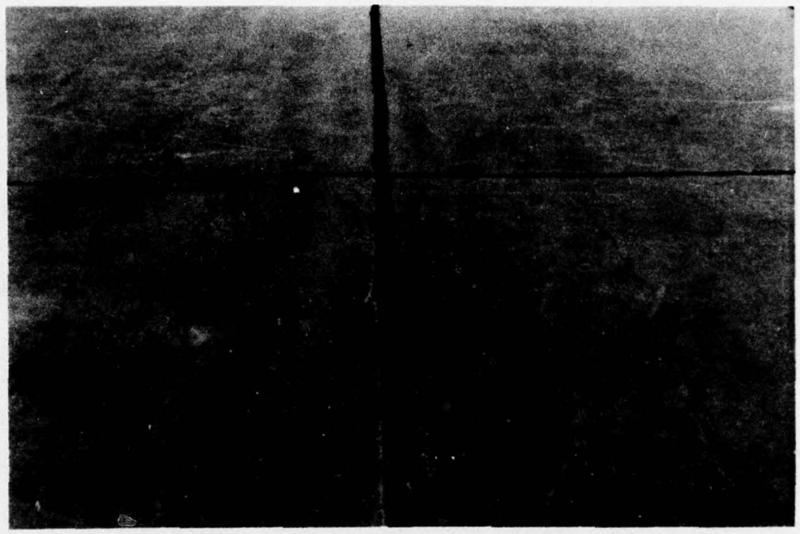


Figure 94. High Severity Joint Seal Damage. (Complete Loss of Sealant; Joint Is Filled With Incompressible Material.)

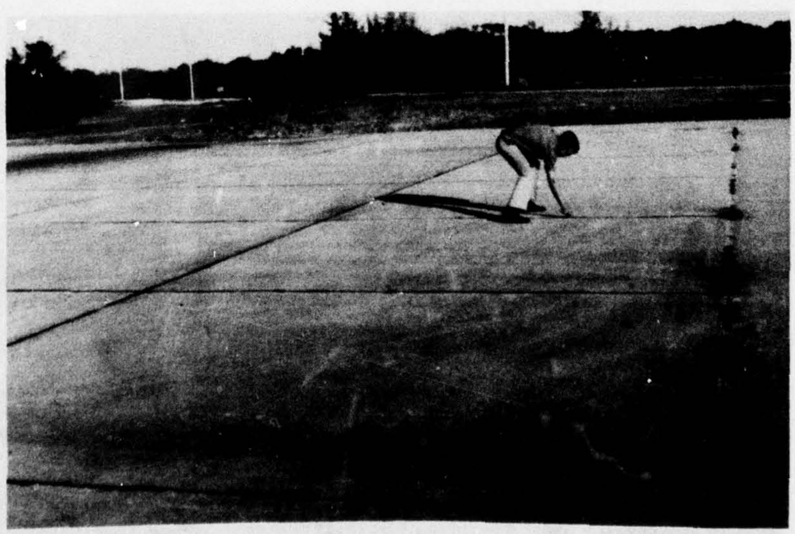


Figure 95. High Severity Joint Seal Damage. (Extensive Amount of Weed Growth.)

Name of Distress: Patching, Small (Less Than 5 Square Feet)

Description: A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5 square feet) and large (over 5 square feet). Large patches are described in the next section.

Severity Levels:

L - Patch is functioning well with little or no deterioration. (Figures 96, 97)

M - Patch has deteriorated, and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort (minor FOD potential). (Figures 98, 99)

H - Patch has deteriorated, either by spalling around the patch or cracking within the patch, to a state which warrants replacement. (Figure 100)

How to Measure: If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded.

Figure 96. Low Severity Small Patch.

Figure 97.  Low Severity Small Patch.

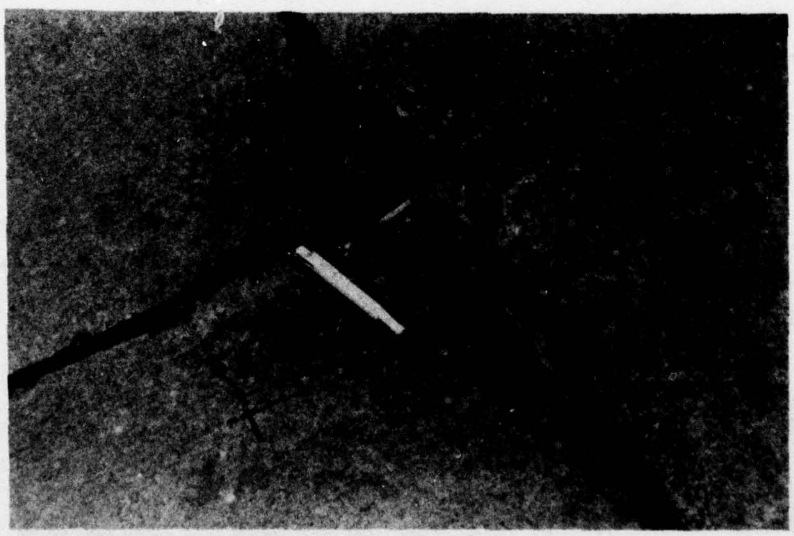


Figure 98.  Medium Severity Small Patch.

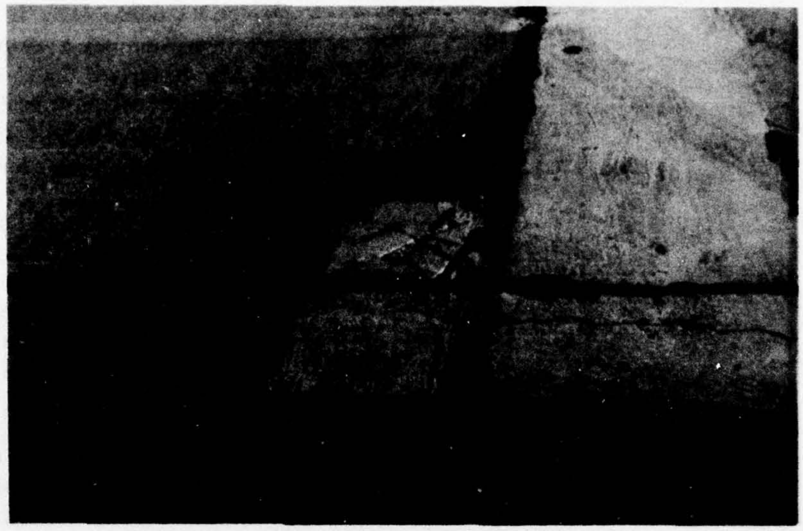


Figure 99. Medium Severity Small Patch.

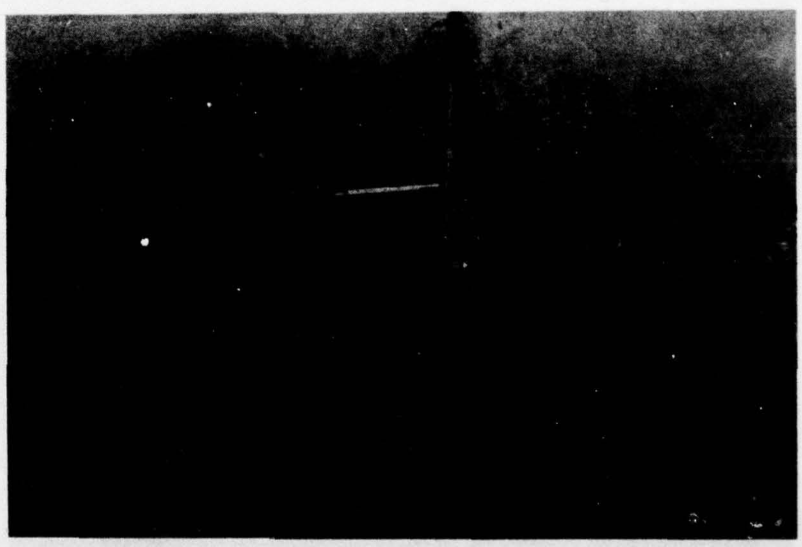


Figure 100. High Severity Small Patch.

Name of Distress: Patching, Large (Over 5 Square Feet) and Utility Cut

Description: Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels:

L - Patch is functioning well with very little or no deterioration. (Figures 101, 102, 103)

M - Patch as deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort, causing some FOD potential. (Figure 104)

H - Patch has deteriorated to a state which causes considerable roughness and/or high FOD potential. The extent of the deterioration warrants replacement of the patch. (Figure 105)

How to Count: The criteria are the same as for small patches.

Figure 101. Low Severity Patch.

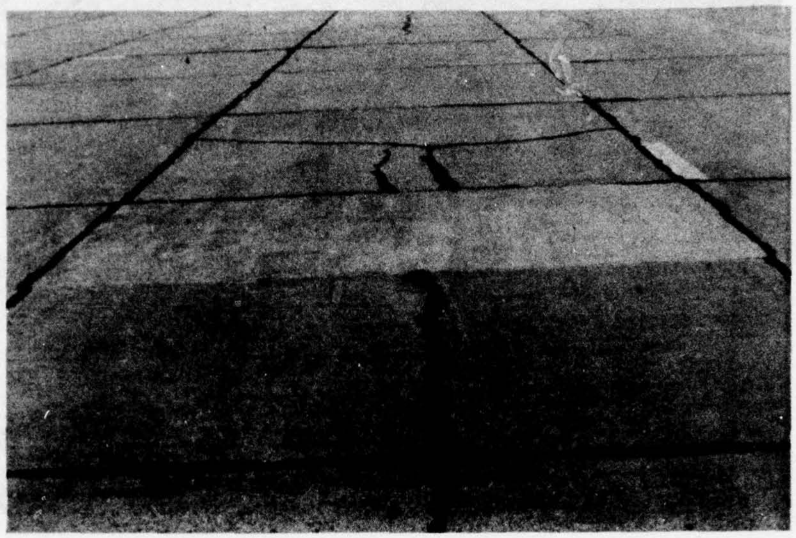


Figure 102. Low Severity Patch.

Figure 103. Low Severity Utility Cut.

Figure 104. Medium Severity Utility Cut.

Figure 105. High Severity Patch.

Name of Distress: Popouts

Description: A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 inch to 4 inches in diameter and from 1/2 inch to 2 inches deep.

Severity Levels: No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; i.e., average popout density must exceed approximately three popouts per square yard over the entire slab area. (Figure 106)

How to Count: The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard, at least three random 1-square-yard areas should be checked. When the average is greater than this density, the slab is counted.

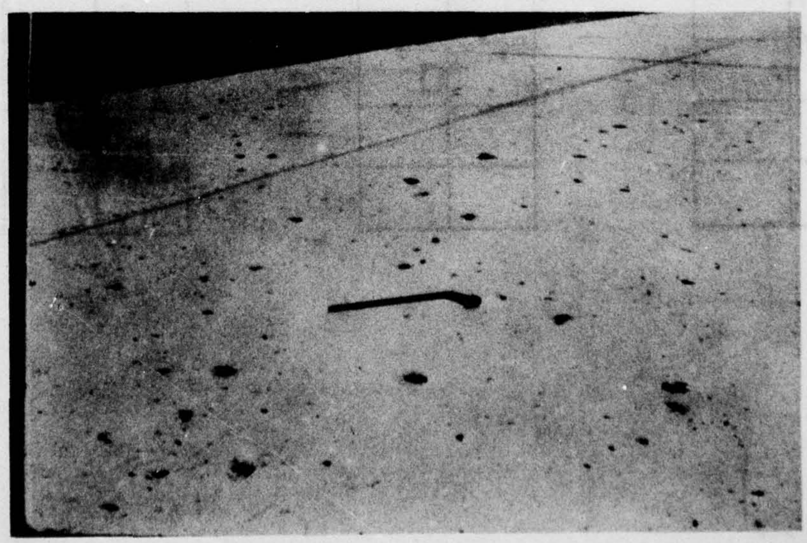


Figure 106. Popouts.

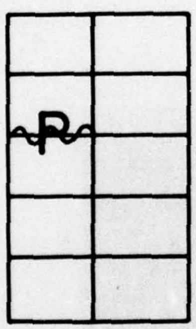
**Name of Distress:** Pumping

**Description:** Pumping is the ejection of material by water through joints or cracks, caused by deflection of the slab under passing loads. As the water is ejected, it carries particles of gravel, sand, clay, or silt, resulting in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support which will lead to cracking under repeated loads.

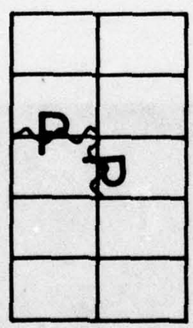
**Severity Levels:** No degrees of severity are defined. It is sufficient to indicate the pumping exists. (Figures 107 through 110)

**How to Count:** Slabs are counted as follows (see diagram): one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint (see diagrams below).

two slabs counted




three slabs counted




five slabs counted

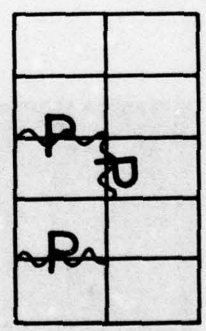


Figure 107. Pumping. (Note Fine Material on Surface That Has Been Pumped Out, Causing Corner Break.)

Figure 108. Pumping. (Note Stains on Pavement.)

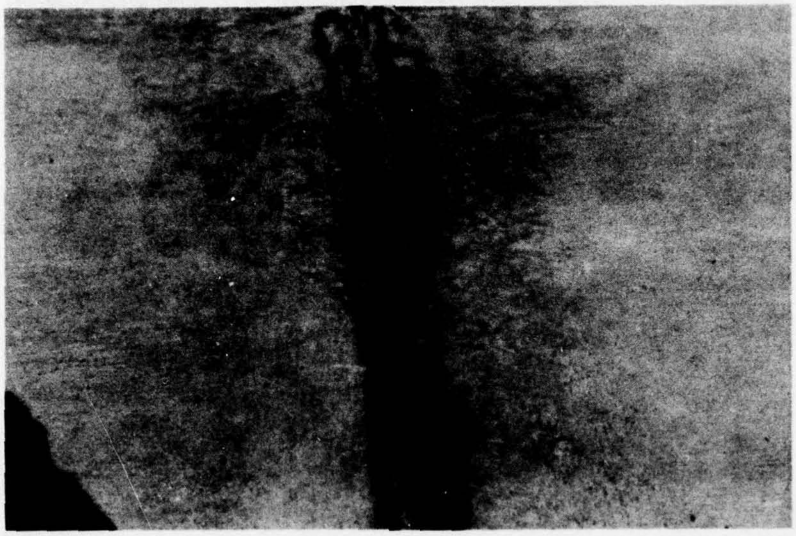


Figure 109. Pumping. (Close-Up of Fine Materials Collecting in the Joint.)

Figure 110. Pumping.

Name of Distress: Scaling, Map Cracking, and Crazing

Description: Map cracking or crazing refers to a network of shallow, fine, or hairline cracks which extend only through the upper surface of the concrete. The cracks tend to intersect at angles of 120 degrees. Map cracking or crazing is usually caused by overfinishing the concrete, and may lead to scaling of the surface, which is the breakdown of the slab surface to a depth of approximately 1/4 inch to 1/2 inch. Scaling may also be caused by deicing salts, improper construction, freeze-thaw cycles, and poor aggregate. Another recognized source of distress is the reaction between the alkalies ($Na_2O$ and $K_2O$) in some cements and certain minerals in some aggregates. Products formed by the reaction between the alkalies and aggregate results in expansions that cause a breakdown in the concrete. This generally occurs throughout the slab and not just at joints where "D" cracking normally occurs.

Severity Levels:

L - Crazing or map cracking exists over most of the slab area; the surface is in good condition with no scaling. (Figure 111)

NOTE: The low severity level is an indicator that scaling may develop in the future.

M - Slab is scaled over approximately 5 percent or less of the surface, causing some FOD potential. (Figure 112)

H - Slab is severely scaled, causing a high FOD potential. Usually more than 5 percent of the surface is affected. (Figures 113, 114)

How to Count: If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. For example, if both low severity crazing and medium scaling exist on one slab, the slab is counted as one slab containing medium scaling.

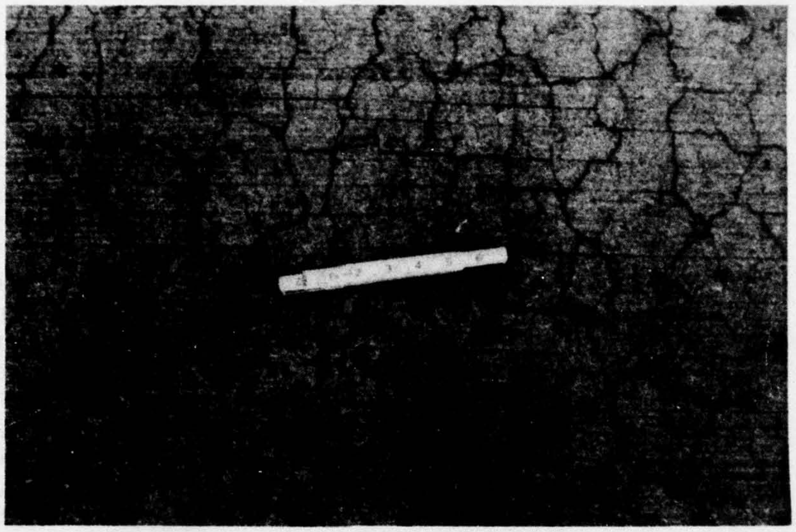


Figure 111. Low Severity Crazing.

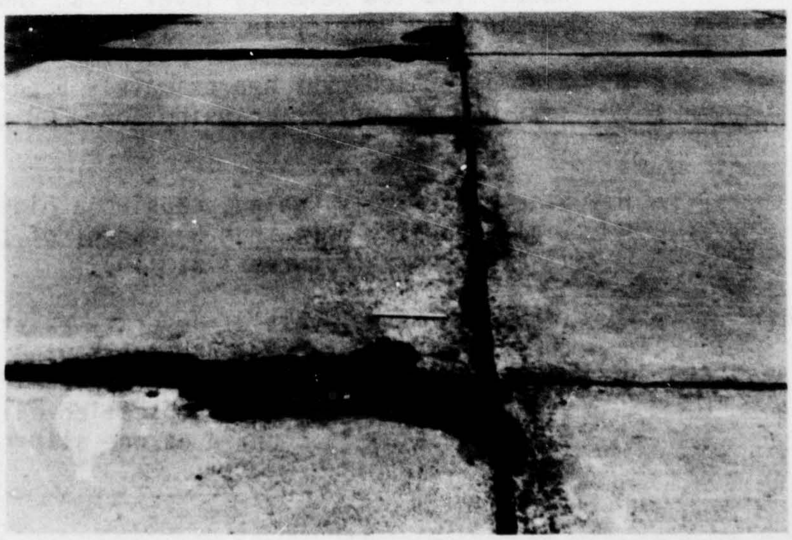


Figure 112. Medium Severity Scaling.

Figure 113. High Severity Scaling.

Figure 114. Close-Up of High Severity Scaling.

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DEVELOPMENT OF A PAVEMENT MAINTENANCE MANAGEMENT SYSTEM. VOLUME--ETC(U)
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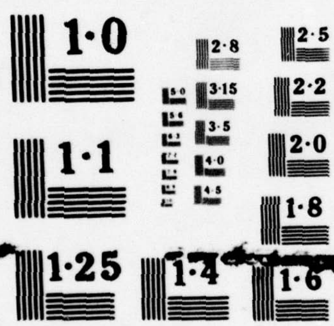


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MICROCOPY RESOLUTION TEST CHART

Name of Distress: Settlement or Faulting

Description: Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

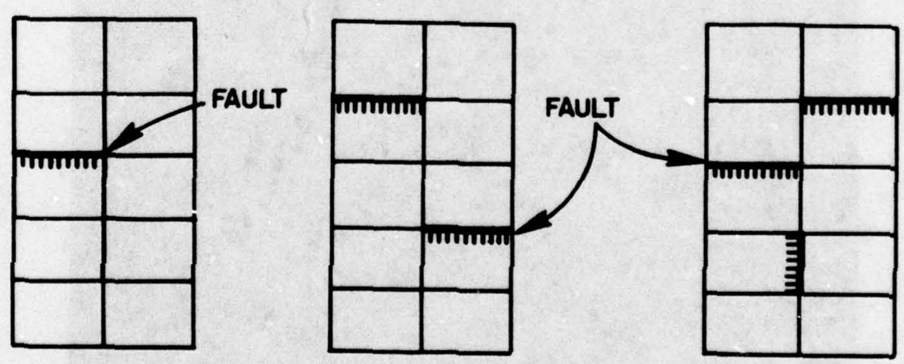
Severity Levels: Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases.

Difference in elevation:

| | Runways/Taxiways | Aprons |
|---|---|---|
| L | < 1/4 inch | 1/8 inch ≤ 1/2 inch (Figures 115, 116) |
| M | 1/4 inch ≤ 1/2 inch | 1/2 inch ≤ 1 inch (Figure 117) |
| H | > 1/2 inch (Figures 118, 119) | > 1 inch |

How to Count: In counting settlement, a fault between two slabs is counted as one slab (see diagram). A straightedge or level should be used to aid in measuring *the difference in elevation between the two slabs* (Figure 117).

one slab counted two slabs counted three slabs counted



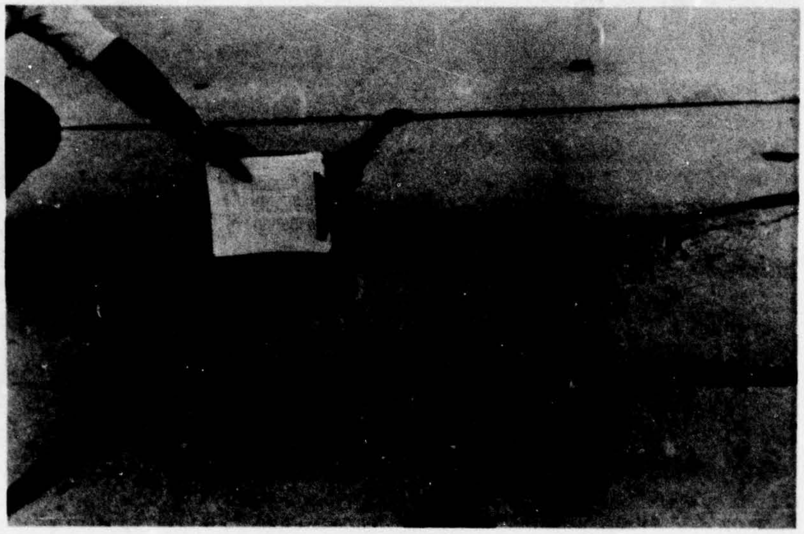


Figure 115. Low Severity Settlement (3/8 Inch) on Apron.

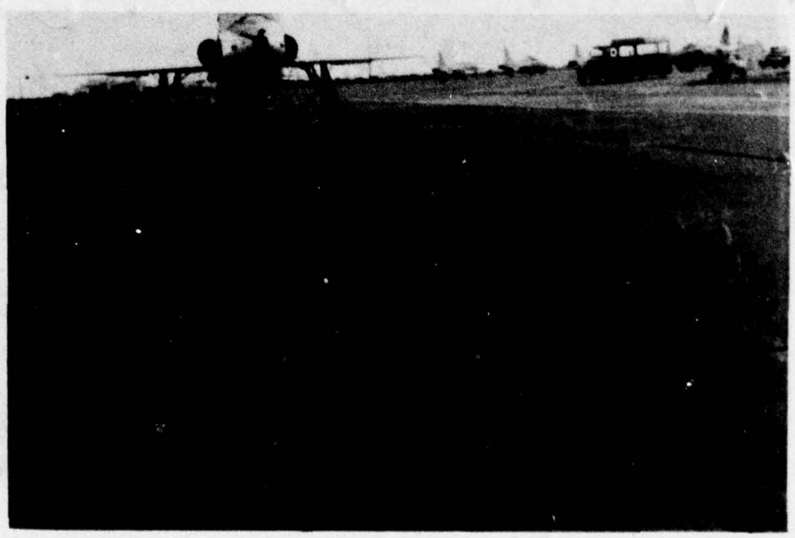


Figure 116. Low Severity Settlement on Apron.

Figure 117. Medium Severity Settlement on Apron (>1/2 Inch).

Figure 118. High Severity Settlement on Taxiway/Runway (3/4 Inch).

Figure 119. High Severity Settlement.

| | |
|---|---|
| Name of Distress: | Shattered Slab/Intersecting Cracks |
| Description: | Intersecting cracks are cracks that break the slab into four or more pieces due to overloading and/or inadequate support. The high severity level of this distress type, as defined below, is referred to as shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break. |
| Severity Levels: | L - Slab is broken into four or five pieces with some or all cracks of low severity. (Figures 120, 121) |
| | M - (1) Slab is broken into four or five pieces with some or all cracks of medium severity (no high severity cracks); or (2) slab is broken into six or more pieces with all cracks of low severity. |
| | H - At this level of severity the slab is called shattered: (1) slab broken into four or five pieces with some or all cracks of high severity; (2) slab is broken into six or more pieces with some or all cracks of medium or high severity. |
| How to Count: | No other distress such as scaling, spalling, or durability cracking should be recorded if the slab is medium or high severity level, since the severity of this distress would affect the slab's rating. |

Figure 120. Low Severity Intersecting Cracks.

Figure 121. Low Severity Intersecting Cracks.

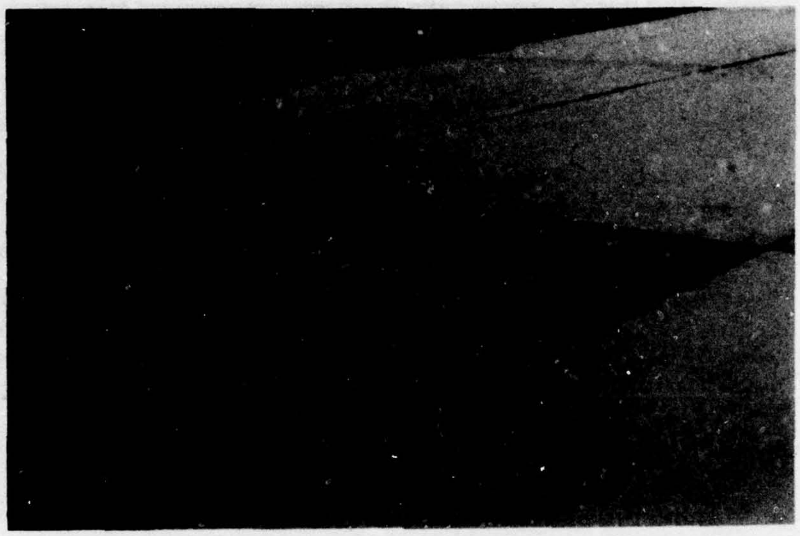


Figure 122. Medium Severity Intersecting Cracks.

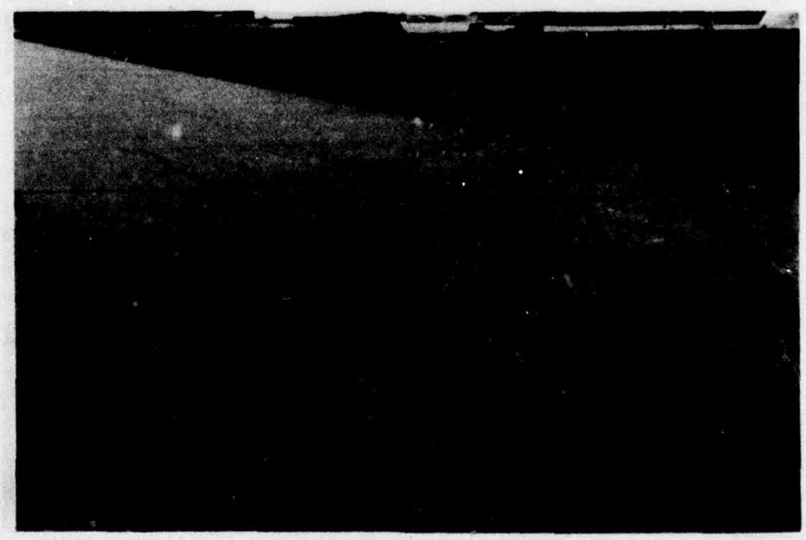


Figure 123. Medium Severity Intersecting Cracks.

Figure 124. Shattered Slab.

Name of Distress: Shrinkage Cracks

Description: Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

Severity Levels: No degrees of severity are defined. It is sufficient to indicate that shrinkage cracks exist. (Figures 125, 126, 127)

How to Count: If one or more shrinkage cracks exist on one particular slab, the slab is counted as one slab with shrinkage cracks.

Figure 125. Shrinkage Crack.

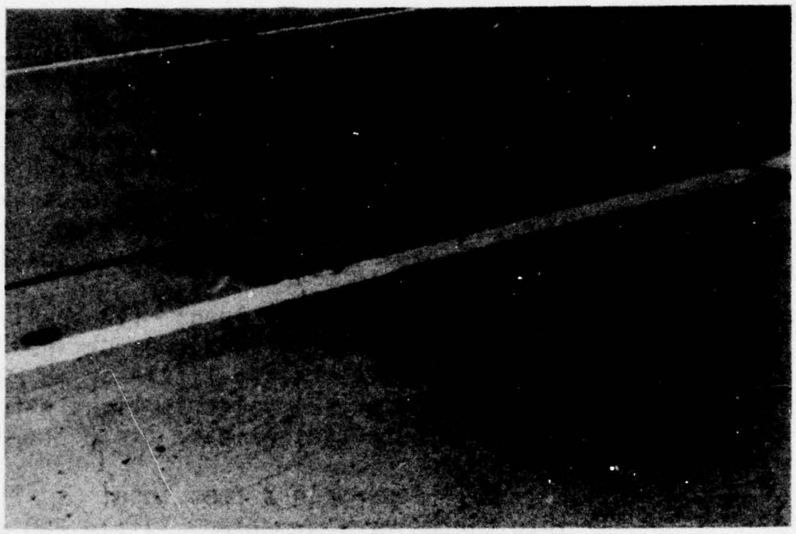


Figure 126. Shrinkage Cracks.

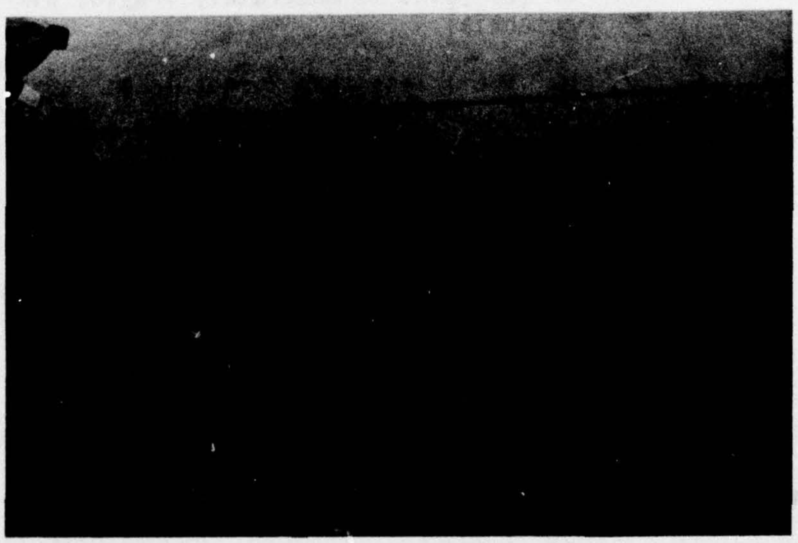


Figure 127. Shrinkage Cracks.

Name of Distress: Spalling (Transverse and Longitudinal Joint)

Description: Joint spalling is the breakdown of the slab edges within 2 feet of the side of the joint. A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic load. Weak concrete at the joint (caused by overworking) combined with traffic loads is another cause of spalling.

Severity Levels:

L - a. Spall over 2 feet long: (1) spall is broken into no more than three pieces defined by low or medium severity cracks; little or no FOD potential exists; or (2) joint is lightly frayed; little or no FOD potential exists.

b. Spall less than 2 feet long: spall is broken into pieces or fragmented; little FOD or tire damage potential exists. (Figures 128, 129, 130)

M - a. Spall over 2 feet long: (1) spall is broken into more than three pieces defined by light or medium cracks; (2) spall is broken into no more than three pieces with one or more of the cracks being severe with some FOD potential existing; or (3) joint is moderately frayed, with some FOD potential.

b. Spall less than 2 feet long: spall is broken into pieces or fragmented, with some of the pieces loose or absent, causing considerable FOD or tire damage potential. (Figures 131, 132)

H - a. Spall over 2 feet long: (1) spall is broken into more than three pieces defined by one or more high severity cracks, with high FOD potential; or (2) joint is severely frayed, with high FOD potential. (Figures 133, 134)

NOTE: If less than 2 feet of the joint is lightly frayed, the spall should not be counted.

How to Count: If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.

Figure 128. Low Severity Joint Spall.

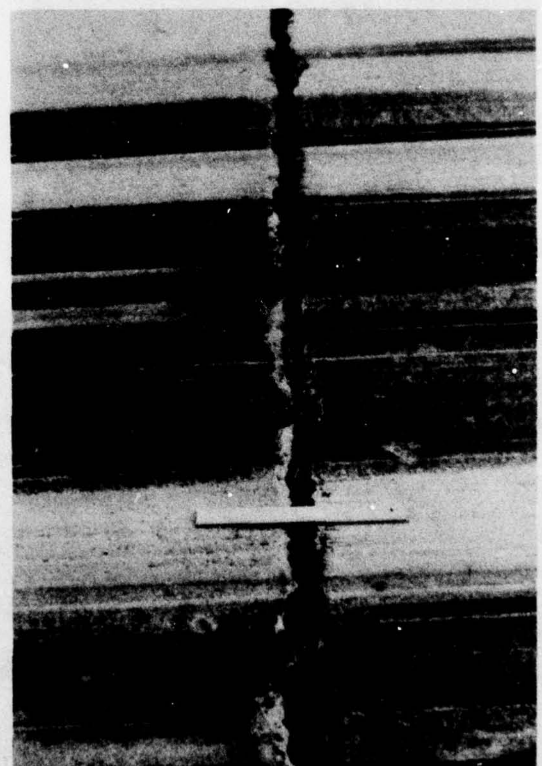


Figure 129. Low Severity Joint Spalling. (If the Frayed Area Was Less Than 2 Feet Long It Would Not Be Counted.)

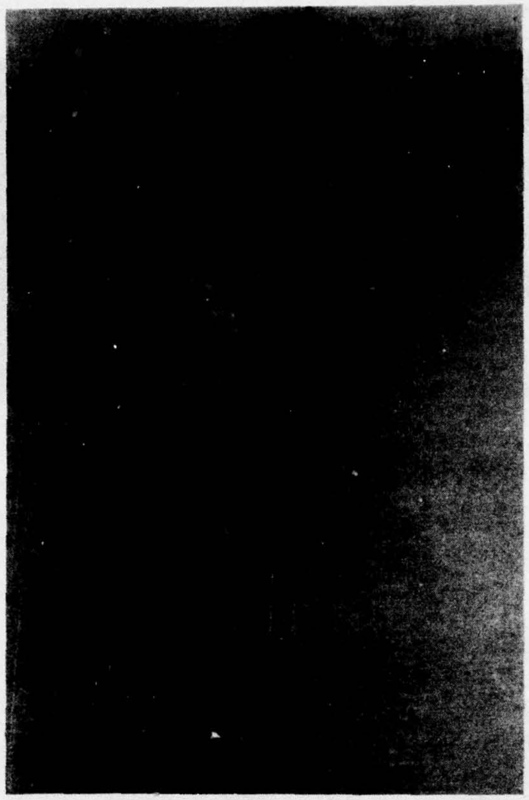


Figure 130. Low Severity Joint Spall.

Figure 131. Medium Severity Joint Spall.

Figure 132. Medium Severity Joint Spall.

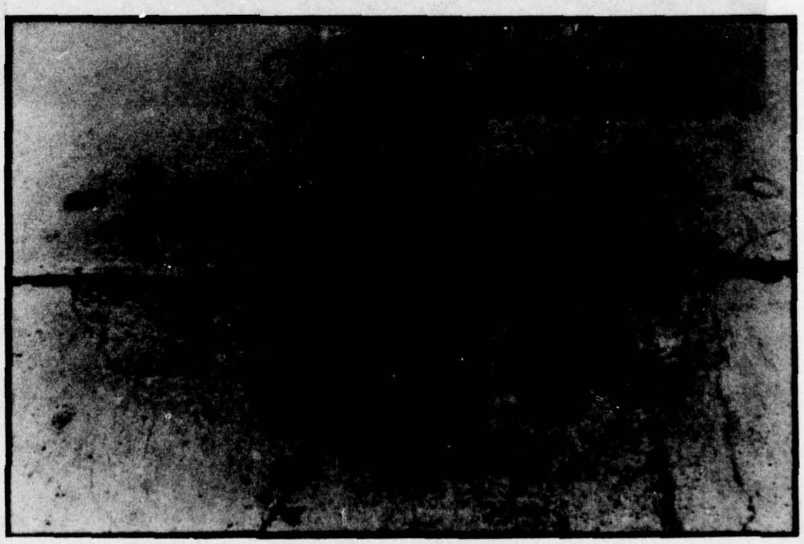


Figure 133. High Severity Joint Spall.

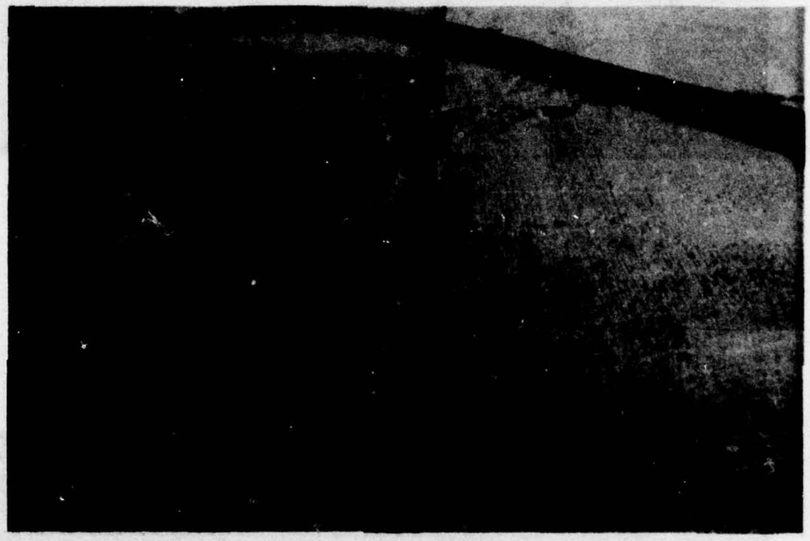


Figure 134. High Severity Joint Spall.

| | |
|---|---|
| Name of Distress: | Spalling (Corner) |
| Description: | Corner spalling is the raveling or breakdown of the slab within approximately 2 feet of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab. |
| Severity Levels: | L - One of the following conditions exists: (1) spall is broken into one or two pieces defined by low severity cracks (little or no FOD potential), or (2) spall is defined by one medium severity crack (little or no FOD potential). (Figures 135, 136) |
| | M - One of the following conditions exists: (1) spall is broken into two or more pieces defined by medium severity crack(s), and a few small fragments may be absent or loose; (2) spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks; or (3) spall has deteriorated to the point where loose material is causing some FOD potential. (Figures 137, 138) |
| | H - One of the following conditions exists: (1) spall is broken into two or more pieces defined by high severity fragmented crack(s), with loose or absent fragments; (2) pieces of the spall have been displaced to the extent that a tire damage hazard exists; or (3) spall has deteriorated to the point where loose material is causing high FOD potential. (Figures 139, 140) |
| How to Count: | If one or more corner spalls having the same severity level are located in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab having the higher severity level. |

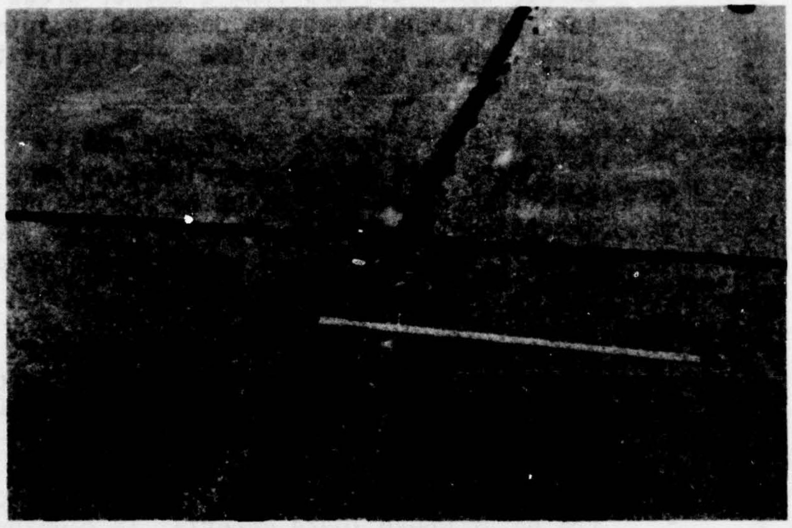


Figure 135. Low Severity Corner Spall.

Figure 136. Low Severity Corner Spall.

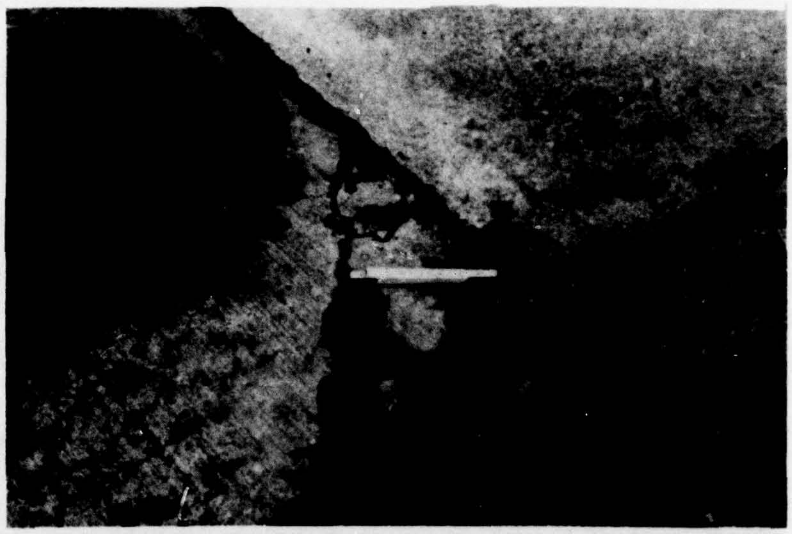


Figure 137. Medium Severity Corner Spall.

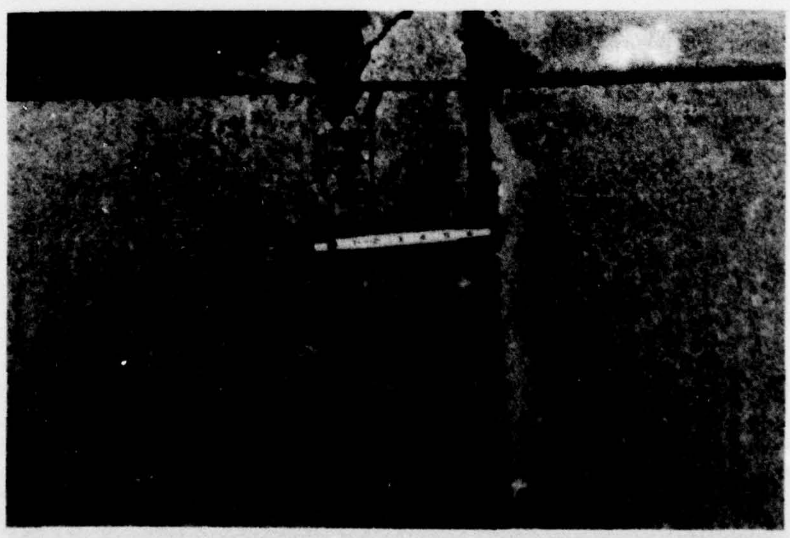


Figure 138. Medium Severity Corner Spall.

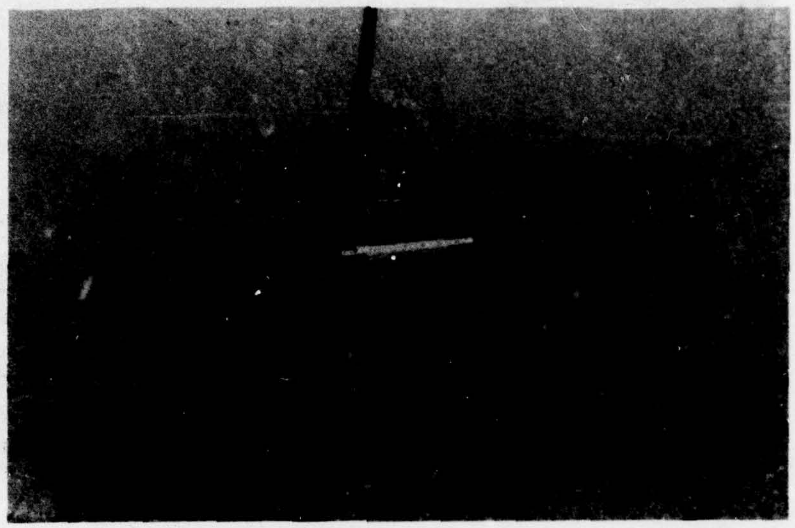


Figure 139. High Severity Corner Spall.

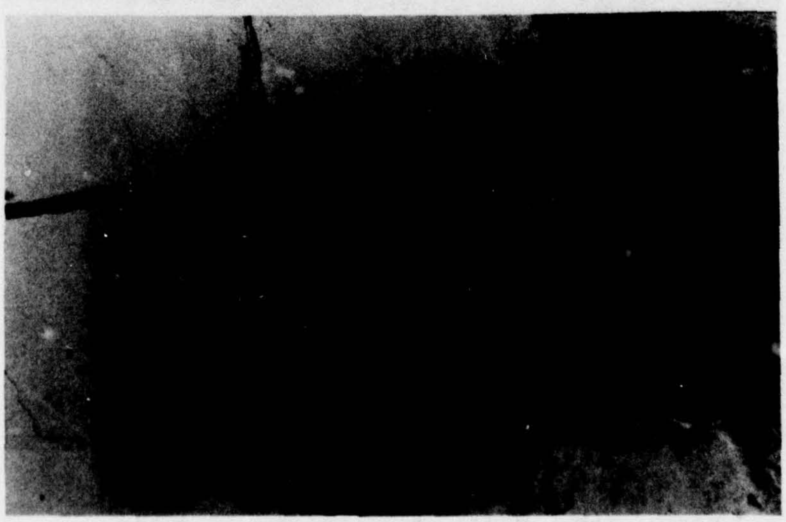


Figure 140. High Severity Corner Spall.